SCIENTIFIC AMERICAN SUPPLEMENT

[UME LXXIV] [BER 1906]

NEW YORK, JULY 13, 1912

[10 CENTS A COPY $5.00 A YEAR]

THE COPPER RIVER BRIDGE, ALASKA, LOOKING TOWARDS THE SOUTH END

The First Span Rests Upon a Concrete Base Set Into Glacial Ice.—[See page 24].

Considerations Before Opening Mines*

Legal and Other Matters

By Arthur J. Hoskin

The word "exploitation" is used by many mining men and engineers to signify a plan of so opening up ore deposits as to render the contents removable. The same persons use the word "mining" to mean the operations involved in the actual extraction of the ore exploited

By "dead work" is usually meant that work of opening up a mine which will put or keep it in a producing condition, but which does not supply any remuneration in the shape of ore (or coal). Again, as used by some men, there is little distinction between this work and exploitation. There may, however, be lines reasonably drawn between these three terms, and therefore the following definitions are proposed:

"Dead work" is such work as is necessary to develop an ore body, but it does not produce any ore. It may be prosecuted for drainage or ventilation purposes or for creating passageways for men and products.

"Exploitation" is also work performed in opening up or developing a property, but it does not contemplate the value of the extracted materials which may, or may not, be of any commercial importance. Indeed, much ore might be extracted during work which was carried on merely to define extents or boundaries of ore bodies. In this last supposition, the original sense of exploration is brought out and this should serve to fix the definition clearly in mind.

"Mining" may be restricted to mean the methods and work involved in the profitable production of the mine's ore (or coal). The term would not be used to cover operations of shaft sinking, tunneling, and the like, unless such work be in the valuable materials. Mining may be said to begin whenever there is produced an output upon which there is some profit. Exploitation may be in valuable ground. If so, we may say that mining is in progress during the exploitation. The driving of levels or drifts in ore body—or entries in a bed of coal—produces the valuable products of the mine, and we may, therefore, consider that mining is taking place.

The driving of a cross-cut, or level, in a vein is either exploitation or mining. Dead work produces *no* ore. Exploitation may, or may not, produce ore. Mining must *produce* ore.

Throughout all of the above and the following discussion, the reader should bear in mind the point that the word "coal" may be substituted for the word "ore" without altering the substance of the definitions or the conclusions.

Before a mine is opened, the economist-manager will consider many items. In the first place, care must be exercised in the examination of the title to the property. A mineral property may have passed through the most complicated kinds of transfers of fractional interests in the title, just as is true with ordinary real estate. The abstract must be traced back clear to the issuance of patent from the government, and then back to the original location. With an undeveloped property (a prospect) this precaution is essential to stop any possible pretensions to ownership by outside parties, in case the ground subsequently turns out to be exceptionally valuable. It has often been the case that no obstructions from any adverse claimants have been met until owners have, in good faith and at great expense, developed splendid mines. Then suits for possession or partial ownership have been instituted, sometimes with marked success for the plaintiffs. There are persons who make it a special line of business to examine titles to mining property, and it is economy for the average manager to employ such experienced men to attend to these matters.

Topographical considerations will hold a place in the study preceding the opening of a new mine. The nature of the surface of the property and the surrounding country will largely influence in the selection of the proper site for the mine's mouth. Neglect upon this point has been a common cause of failure in mining operations.

A mine opening must be away from all dangers of snow slides, rock slides, cloud bursts, and deluges from overflowing streams or breaking dams. It may make a difference in the mine's ventilation as to which direction the prevailing winds blow and therefore upon which side of a hill the mouth be opened.

Transportation facilities must be given due thought. If means are not already at hand, one must inquire into the feasibility of constructing some form of carrier; and here, again, will enter the question of the surface contour. If a railroad is out of question, possibly an aerial tramway may be considered. These modern conveyances stop at no obstacles of surface configuration and are dependent only upon the necessity of having the point of delivery lower in altitude than the point of loading at the mine. With some of the modern improvements in these installations, mine products are being transported up hill as well as down hill, through the application of power. In mining regions it is generally the case that the mines themselves are above the settlements in which are the railroads or treatment plants, so that the mine products may be conveyed readily by the natural force of gravity.

Climate holds an important place in the economics of mining. A very rich piece of ground may prove a losing proposition in some portions of the world where the climatic conditions are such as to render operations possible during only a very small portion of the year. Extremes of heat or cold, malaria or other pestilential obstacles, long rainy seasons with floods, or the hostility of native humans, beasts, or insects have accounted for the abandonment of seemingly attractive mining projects.

The question of labor must be given due thought. It is true that the best miners on earth are Americans. We do not deny that many of our miners are of foreign birth, but the fact remains that they (these acquired Americans) perform better and more intelligent service than do their fellow countrymen who have been adopted into our country. Our men are in demand in the mining development of foreign countries. An American mine manager will always experience dissatisfaction while endeavoring to get, from natives in foreign parts, the same efficiency that he is accustomed to receive from the miners "in the States." He may be paying a good deal less per capita for such labor, but he finds he is actually paying more per ton of output.

Within a single country, there are notable differences in the worth of labor. The natives of some of the Mexican States are far preferable to those of other States. Even within the United States there may be discerned material differences between the efficiencies of the inhabitants of various sections when it comes to mining. One cannot procure as competent miners in some of the agricultural States as in the typical mining States. This is but to be expected. For instance, there are deposits of lead ore in the "moonshine" regions of Kentucky which have never been successfully worked, and the real cause of failure, in the writer's belief, lies in the inability of superintendents to obtain miners either from that region or from the outside. The residents will never become miners; outsiders will not enter for work under existing sociological conditions.

The question of unionism is sometimes held by managers as a deciding one when debating the opening of a mine. While there are those who will broadly denounce such organizations, there may be found other, and just as successful, mine operators who declare that the effects of union control over their miners are beneficial to their companies' interests.

On the other hand, there are mine managers who prefer the presence of some central, labor-controlling body; for they believe that the men who belong to such a large federation or organization will, and do, have less complaint to make and therefore work more freely than is the case with the independent laborers. The argument is that these union men are satisfied because they feel that their interests are being looked after with a sort of attention that they, individually, could not give.

This is not a place to discuss the crimes that have been laid at the doors of both the labor organizations and the mine owners' associations. It is safe to assume that wrong has probably been done upon both sides. But, it is furthermore right to believe that most of the crimes were not authorized, nor recognized, by the officers of either side. Individual members must not be taken as averages of the membership in any kind of civil, social, or political organization.

It seems entirely wrong that politics should enter into the considerations of a mine manager whose operations are apparently so apart from affairs of state; but the fact remains that there are places where mining operations cannot be carried on without the good-will of certain officials of the State or National governments. It is not advisable to enter into any compromising terms to gain privileges for carrying on any legitimate business, for there are other, better ways, generally, of attaining the justice that is deserved.

One must not omit to investigate the sources of su ply for all the needs of a mine and its camp. The are many kinds of material needed to keep a mi going. Fuel, machinery, timber, water, food for me and beasts, lumber, and all household furnishing a necessities must come from some markets or natur sources. It behooves the cautious manager to see th all these things may be had in ample amount and figures which will not prove annihilating to h business.

In Utah, there are mines which have all their ti bers framed in and shipped from the forests of Orego the sawing and framing being done before shipment, save in freight. The fir of Oregon is shipped to di tant Australia for mining purposes. The arid cam of Nevada get their supplies of timber from the sist State, California. The Michigan mines are fortun in being in a lumber region. Colorado's metal min are more favored in the matter of timbers than are t coal mines of the same State. Most of the coal min are upon barren plains, while the metal mines a chiefly in the wooded mountains.

Water may be too scarce for the needs of a mine its community. There may not be sufficient to supp boilers of a mill, or for the domestic purposes of t workers. On the other hand, water may be so ab dant in the mine workings as to prove a deterrent f tor in profitable operation. With shaft mines, fr which water must be delivered mechanically, the co of such drainage are frequently prohibitive of mini with deep workings and low grades of ore. Some mi in arid regions have been fortunate in striking su flows of underground water that it has been possible operate mills right at the mines. In this way, the c of water hoisting has been more than compensated the milling benefits which, in turn, have decreas freights and treatment charges.

The nearer a property is to a depot of supplies, t less is bound to be the cost of getting goods on t ground. It is this last item, the delivery of goods, th must be recognized as a very pertinent and sometim a critical factor upon the cost side of mining accou Mines that are remote or in rugged countries are f quently dependent upon animal transportation. some cases, machinery going to the mines must be built that it may be taken apart into small porti suitable for loading upon the backs of horses or burr or even, in the Andes, upon the frail llamas.

Operations, if planned to be conducted for a lo term of years and therefore warranting the installati of large and expensive plants, should be based upon t holding of extensive ore-bearing ground. Here ent the notion of the shape and size of a mining proper

With some kinds of mining ground, the best form the holdings would probably be a compact, appro mately equilateral tract, covering a reasonably la acreage. This would be the case with ores that oc in sedimentary beds, for instance, where it is advisa to have the mining plant centrally located so as to peditiously work the entire area. This would a apply to a region like the Cripple Creek district wh contains innumerable veins running in all directi but displaying no outcrops.

In other instances, the most desirable shape might long, narrow strips so laid off as to contain the stri of persistent lodes or veins, as those of the wonder Comstock Lode region. The great Camp Bird mine the San Juan region of Colorado was expected to worked for many years to come because its own exercised the precaution to possess the ground, miles, containing the extension of the persistent v from which millions have been taken. It is not ac age that counts here so much as linear extent.

In the Transvaal, land is held in rectangular bloc The first owners of the ground took it up for agric tural purposes. This same statement is also true of mining properties in the Joplin district of Missouri a Kansas.

In the case of the South African properties, eve company has definite boundaries to which operatio may be planned. Hence it is possible for the mana ment to so plan any mine as to operate it at given r for a predetermined life of the enterprise. The w is planned to maintain a certain output that will haust the ore bodies in just so many years, and all t equipment may thus be purchased with the fore that it will serve its purpose and perform its econo share within the prescribed time.

* Reproduced from *Mines and Minerals*.

Methods of Testing Coatings for Cement Surfaces*

Most Preparations on the Market Have Not Yet Stood the Test of Time

By Cloyd M. Chapman

The increasing use of concrete for building construction of the better class, and the use of cement stucco as an exterior finish for residences, have afforded a market for preparations intended to decorate and to dampproof surfaces of this nature. The necessity for dampproofing such structures above grade is due largely if not entirely to imperfect workmanship or improper selection of the materials used in the structure or to both. Nevertheless there are cases where a suitable dampproofer would be of value if one could be found.

As to decorative coatings, it is possible to produce in concrete or mortar such a variety of color and texture effects, which are lasting and pleasing, that it seems like attempting to "paint the lily" to put a coating on them. However, there are conditions under which it is economical and expedient to use a paint or coating on concrete or mortar surfaces, provided a fairly durable article can be found for the purpose.

The painting and dampproofing of concrete is not an old and well established art like the painting of wood and metal, but most of the preparations on the market are comparatively new and have not had the test of time. To use some of them would mean the disfigurement of the surface rather than its decoration.

It is often desirable to compare first the qualities of two or more products before deciding which of them to use. The testing of such materials is often difficult and technical, requiring skill and special apparatus. There are certain simple practical tests, however, which may be applied by anyone who will take the time and which require very little apparatus or skill. The following tests were devised for use in the laboratory of Westinghouse, Church, Kerr & Co. and have been in use for several years. They are recommended for their simplicity and the practical comparative results obtained. They have been adopted, in some cases modified, by several other laboratories and by makers of the class of products they are designed to test.

CLASSIFICATION.

In these tests of concrete waterproofers and dampproof concrete coatings, the materials are divided into the following classes:

Colorless Dampproof Coatings.—This class includes all preparations intended for surface application for the purpose of excluding dampness, which the makers claim will not change the appearance of the surface to which they are applied.

Black Waterproof Coatings.—This class includes all tar, pitch, and asphalt preparations and other black waterproofing paints. Such coatings should be able to withstand some pressure head of water and are therefore termed waterproofers. They would not be used where a decorative effect is required.

Integral Waterproofers.—This class includes all materials for waterproofing, whether pastes, powders or solutions, that are incorporated into the mass of the concrete at the time of mixing.

Colored and White Concrete Coatings.—This class includes all coatings of a decorative nature intended for exterior use. Many of the paints in this class are recommended by the manufacturer for their dampproofing qualities.

This test is intended primarily for the first two classes, although many paints in the last class when especially recommended as dampproofers are included.

The test piece is a 3 to 1 sand-cement mortar block 3½ inches square by 2 inches deep, with a depression in the top 2½ inches in diameter by about ⅞ inch deep made by inverting a telephone bell in the mold. The mold is of ⅞-inch oak, and is made in two right angular pieces which hook together at opposite corners, so that it is easily removed by unhooking and drawing apart.

To obtain a porous block which will absorb 30 cubic centimeters of water in more than 1 minute and less than 2 minutes, the sand and cement are gaged with from 9 to 10 per cent of water by weight, this percentage being figured on the total weight of sand plus cement, and tamped evenly into the mold. Some difficulty may be found in making blocks of the proper porosity; that is, just dense enough to absorb the 30 cubic centimeters of water in not less than 1 minute or more than 2 minutes, but after some experimenting with different percentages of water and different degrees of tamping, the proper result is obtained.

Denser blocks are made in the same manner but the percentage of gaging water is higher and may run up as high as 20 per cent.

All blocks are kept in a damp closet for 24 hours and then allowed to dry out in air for at least one week before being used.

*Reproduced from the *Engineering Record.*

After the block has dried out 30 cubic centimeters of water are placed in the depression and the time required for the block to absorb this amount of water is noted. The blocks are divided into two classes, those which will absorb the water in the time limit and those which take less than 1 minute or more than 2 minutes to absorb the 30 cubic centimeters. The latter are considered too porous for a proper test.

After this treatment the block is again thoroughly dried out and the time required to absorb the 30 cubic centimeters of water is recorded on the block, which is now ready for use.

The blocks which take up water in 1 to 2 minutes are considered as standard, but materials are tested on both porous and dense blocks for comparison. Each block is given a number for purpose of identification. Porous or standard blocks are numbered consecutively from 1 to 500 and the denser one from 500 up.

The waterproofing coating is applied only to the surface of the depression and to the top surface of the block, and two full, liberal and thoroughly brushed in coats are applied, the first being given at least two days to dry out before the application of the second. Not less than one week after the application of the second coat, the block is ready for the first test.

TWENTY-FOUR HOUR ABSORPTION TEST.

The block is first weighed dry and then 30 grammes of water are placed in the depression. It is then allowed to stand for 24 hours, with a watch glass over the depression, after which time it is weighed again. The loss in weight is the evaporation. The water is then thrown out and the block wiped dry and weighed again. The loss from the weight including water is the absorption. The following is a tabulation of the different weighings taken:

1. Weight of block dry plus watch glass.
2. Weight of block plus 30 grammes of water plus watch glass.
3. Same as 2 but after standing for 24 hours.
4. Weight of block plus watch glass, after water has been thrown out and the block wiped dry.

Weighings: 2 minus 3 gives weight of water lost by evaporation, and 3 minus 4 gives weight of water in block after 24 hours.

The watch glass almost completely prevents evaporation from the surface of the water. Before any appreciable amount of the water in the depression can evaporate it must pass through the waterproof coating and be evaporated from the surface of the sides or bottom of the block. The most efficiently waterproofed blocks are those which show the minimum amount of absorption and evaporation.

ABSORPTION TIME TEST.

The 30 cubic centimeters of water are placed in the depression in the block and covered with a watch glass to prevent evaporation. A paper is placed over the whole to exclude air currents. The block is examined from time to time until all the water in the depression has disappeared. The time required for the block to absorb the 30 cubic centimeters of water is recorded. If all the water has not been absorbed in three weeks' time the approximate percentage absorbed in three weeks is recorded.

The length of time taken for the water to be absorbed by the block is an indication of the efficiency of the waterproofing film or coating.

The block is then exposed in the open air to find the effect of weather exposure on the coating. It is brought in at intervals of about three, six and twelve months and the same tests as above described are repeated. The decrease, if any, in the efficiency of the coating is noted after each repeated exposure.

TEST OF INTEGRAL WATERPROOFING.

For this test the blocks are made up of a 1 cement, 3 sand mixture plus, the waterproofing paste, powder or liquid. The waterproofing compound is incorporated in the mix according to the directions as given by the manufacturer. The mixture is gaged in all cases with the proper amount of water to give approximate maximum density. The consistency resulting from this amount of water gives a rather wet quaking mortar, but one from which no free water will rise to the surface on tamping.

This block is identical in size and shape with that previously described. It is kept in the damp closet for 24 hours after making and is allowed to dry out in air for at least one week before being tested.

The tests on these blocks are the 24 hour absorption, and absorption time tests, and are identical with those described above.

TEST OF CONCRETE COATINGS.

This class comprises, chiefly, coatings of a decorative nature, intended for exterior use. The paints in this class are tested on the outer face of hollow cubes, the faces of which are about 9 inches square, with walls from 1 to 1½ inches thick. These hollow cubes are made of a 1 cement, 2½ sand, 4 gravel mixture; and gaged to a rather wet mixture into a 9x9x9-inch wooden form provided with an iron core about 12 inches high and 6 inches square. The bottom of the block is made about 1½ inches thick, and the hollow iron core is then placed on it and centered up, after which the concrete is packed in between the core and the form.

The core used has considerable taper so that it may be easily drawn out after the concrete has begun to set. After the block has had 48 hours to harden the wooden form is removed and the faces are finished with a 1 cement, 2 sand mortar. In finishing the faces the mortar is mixed rather wet and is merely rubbed into the surface with a wooden float to give a smooth surface. The block is ready for use not less than one week after date of finishing up the sides.

Before applying any paints the block is given a number, marked on the inside of one of the faces, and the faces are numbered from 1 to 4, marked at the middle of the top edge. The date of making the block is recorded.

A few minutes before applying a paint, the bottom third of the face to be painted is thoroughly dampened by applying water to it with a brush. Care is taken to wait until no visible water is on the surface before the paint is applied.

APPLYING FIRST COAT.

In applying the first coat the paint is thoroughly brushed in so that it will penetrate all small irregularities of the surface. The second coat is applied not less than two days after date of application of the first.

At the time of painting the fact is recorded that the bottom third of the side was dampened. The following data are also noted at this time: Number of block; number of side; name of maker and name of paint (for both coats); entry number of paint; date of painting; percentage of sediment in the paint can when it was opened and consistency of this sediment; ease of application of paint, ease of mixing paint; hiding power of paint.

After the second coat has thoroughly dried, the general appearance of the painted surface is recorded. The points noted in regard to appearance are as follows: Dull or glossy; whether surface is smooth or granular; whether brush marks are visible or not; whether paint fills well or poorly, i. e., whether the irregularities of the concrete surface are well fitted up by the paint or not.

THE SCRUBBING TEST.

After all four sides of a block have been painted with two coats, and at least three days after the application of the final coat, the painted surfaces are scrubbed lightly with a medium bristle scrubbing brush with powdered soap and water. The effect of this scrubbing is noted in detail, as to whether the coating is softened, or whether the paint scrubs off, and if so, to what extent.

After the scrubbing test the block is allowed to dry out and after not less than one day from the time of scrubbing, it is filled with water and kept filled for a period of five days. If the water leaks through either the sides or bottom of the block to any appreciable extent, the inside of the block is given a neat cement wash to remedy this condition.

After the water has been in the block for a period of five days it is emptied out and the condition of the coatings on the different faces is carefully examined and recorded. Conditions resulting from the five days' water test to be noted are as follows: Softening of coatings; excrescence; discoloration of coating; cracking or blistering of coating; flaking off of coating.

After the block has thoroughly dried out the coating of the four faces are given a general comparative rating according to their respective general appearance and condition.

WEATHER EXPOSURE.

The block is now ready for the weather exposure test, and for this purpose it is exposed in the open air, and is placed with the bottom side up. Examinations of the blocks are made at regular intervals of about three, six and twelve months. Conditions resulting from weather exposure to be noted are as follows: Chalking of coatings; checking and cracking of coating; sealing or flaking off of coating; fading or discoloring.

As was pointed out above, the coating of concrete is a comparatively new art and we have practically no stock methods and materials to guide us, but the simple indications here given should be found useful in working out each separate case as it arises.

Ceylon: The Island of Jewels*

A Rich Industry Monopolized by the Natives

By Leopold Claremont

THE gem-minerals with which Ceylon is so generously endowed are remarkable, not only for their beauty, but also on account of the great variety of them.

Although the diamond, opal, emerald, and peridot are conspicuous by their absence, all the other well-known transparent gems are abundantly represented in the island. There are also many very beautiful precious stones with which the general public at all events is more or less unfamiliar.

Fig. 1.—Crystals of Adularia or Moonstone (actual size).

These gems are almost colorless and transparent by transmitted light, but display when cut with a smooth convex surface (*en cabochon*) a white or bluish blush or spot from which they take their name.

The principal mineral is corundum, of which the red and blue varieties constitute the gems ruby and sapphire. (See Fig. 4.) It, however, also occurs in a long series of different colors of varying shades, which range from the ruby-red to delicate rose pink; from the royal sapphire to sky-blue; from plum to violet and lilac; and from golden orange to primrose.

There is also a most attractive rich salmon-pink variety, resembling the tint of the "Sunrise" rose, and which is known to Ceylon as *patparagum*, and very rarely only, the mineral is found green in the island.

In Central Queensland, however, at a place called Anakie, the green variety is fairly plentiful, while the red and purple are entirely absent.

Some of the corundum gem-stones exhibit the phenomenon of *asterism*, that is, they display a bright shimmering six-pointed star with the rays divergent from the center of the stone when it is cut with a smooth convex surface.

They are found almost exclusively in Ceylon (a few ruby star-stones are found in Burmah), and under the name of *asteras* or *star-stones* are highly valued by connoisseurs when of choice quality. For some unknown reason, the yellow and green varieties of corundum do not exhibit the phenomenon of asterism.

Another gem-mineral which possesses a similarly extensive range of color, except that yellow is missing, is the spinel. Some specimens of this somewhat resemble rubies and sapphires, and are therefore often described as "spinel rubies," and "spinel sapphires," respectively. It is, however, very much softer than corundum, and is one of the three gem-stones, occurring in the form of crystals, which are singly refractive, the other two being diamond and garnet.

There is a remarkable flame-red variety of spinel, the color of which is unique in the whole mineral world, not even excepting the ruby. It is an exquisite gem of great value.

The chrysoberyl is an attractive gem stone, although its beauty is somewhat unappreciated. It occurs in shades of Autumn green, brown, and yellow, and possesses great brilliancy. There are, however, two varieties of this gem-mineral which form well-known and valuable precious stones; of these, the most important is known as the *alexandrite*. (See Fig. 2.) Fine examples of this gem by daylight appear pistachio-green, changing to rich mulberry-red by artificial light.

Ceylon is the chief source of alexandrites, although a few are found in Siberia.

The other important variety of chrysoberyl is the *cymophane* or cat's eye, which, when cut with a smooth convex face presents a narrow white line glittering across it, which has a fancied resemblance to the iris of a cat. The position of the line or ray alters as light strikes it from different angles, giving a peculiarly mysterious effect. Cymophanes are only found in Ceylon.

The rarest and most curious of all precious stones are those cat's eyes which change from green to red, as do the alexandrites.

By the superstititous natives the cymophane is considered to be an entombed spirit, and this can be more readily understood than many other similar conceits, because of the strange resemblance of the stone to the eye of an animal.

Many shades of soft yellow, brown, cinnamon and green are displayed by specimens of the mineral jargoon or zircon. (See Fig. 3.) This gem-stone is strangely unappreciated, for not only is the coloring most pleasing, but the brilliance is second only to that of the diamond.

Another reason why the neglect of the zircon is unaccountable is that this beautiful gem is comparatively inexpensive.

The writer has only space briefly to complete the list of precious stones of Ceylon, for his object is to give the reader some idea of the manner in which they are handled.

There are garnets, red, brown, violet and cinnamon; topazes, white and blue; tourmalines, red, claret, green, yellow and blue; aquamarines or beryls, sky-blue and sea-green; besides iolotes and moonstones. (See Fig. 1.)

From the foregoing paragraphs it should be apparent that these gems present a pageant of color unequalled by those of any other district.

From the finding of a precious stone in a river bank or gem pit, to its use as a jewel by a woman of fashion, it passes through many strange hands, and undergoes much alteration in appearance.

The securing, cutting, polishing and marketing of such a large number of gems necessarily comprise an important industry. The entire trade is controlled

* Reproduced from *Knowledge*.

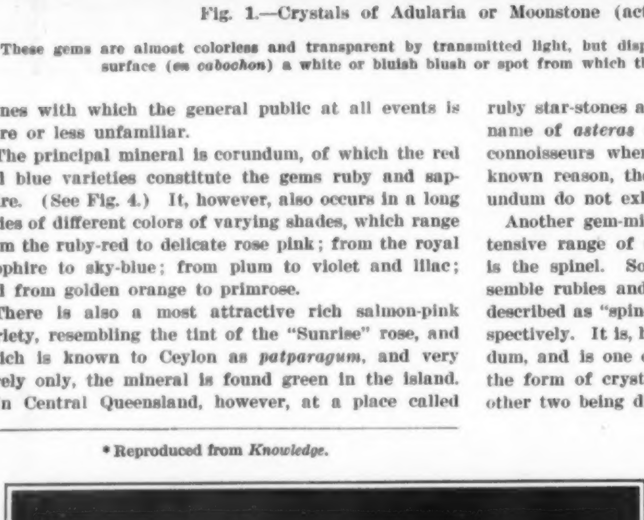


Fig. 2.—Crystals of Alexandrite (actual size).

The alexandrite and cat's-eye are both varieties of the mineral chrysoberyl, and in very rare cases the cat's-eye variety also possesses the power of alteration of color. Although Ceylon is the chief source of the alexandrites and the sole source of the cat's-eye, the most choice specimens of the former are derived from Siberia.

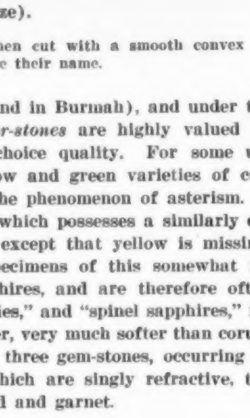


Fig. 3.—Crystal of Jargoon or Zircon (actual size).

When cut as facetted stones, jargoons possess the power of dispersion of light approaching in some cases to that of the diamond.

Fig. 4.—A Somewhat Water-worn Crystal of Sapphire.

Fig. 5.—Natives of Ceylon Working a Gem Pit.

Fig. 6.—The "Gemming" Basket in Use.

Fig. 7.—The Basket is Handled With a Circular Movement.

locally by the Moormen, many of whom are extremely wealthy.

The foremost of them not only buy up the most important stones as they are found from time to time, but send out expeditions into the principal gem-producing areas to search for them. They all either retain their own cutters or superintend the work given out to be done. No foreigner is admitted within the magic circle of the Moormen except as a customer.

The Moormen are descendants of the Moors who once occupied Ceylon, and of whose forts large ruins still exist in the island.

The value of the precious stones annually exported to Europe and America from Ceylon is estimated at fifteen million dollars, and high prices, especially for choice specimens, are realized locally from travelers and tourists.

Fig. 8.—The Lighter Stones Slip Over the Edge of the Basket.

The gem-stones are of igneous origin, and have been loosened from the granite and gneissic rocks in which they were formed by disintegration. They are found in a stratum of alluvial gravel which is known to the natives as "illam," which is reached by digging pits of from three to thirty feet in depth. They are generally in the form of more or less water-worn nodules, undamaged crystals being very rare. (See Fig. 4.)

When the pits are deep, the illam is hoisted to the surface by means of a primitive kind of wooden crane, and it is then carried to the nearest stream or pool to be washed.

It is often found, in low-lying spots, that old disused gem pits which have become filled with water are available for the washing of the gem-bearing material.

The illam consists of gravel embedded in yellow or reddish clay, and is usually brought to the surface in a dry condition, but when the gem pit is below the level of a neighboring stream it is rather muddy.

Sometimes the stratum of illam *crops out*, or is exposed upon the surface of the country, and this is generally found to occur on the slopes and banks of rivers and streams. When this is the case very little excavation is done, as the material is more easily obtainable.

The searching for gems is carried on from October to March. The washing is done by means of a circular basin-shaped basket, about twenty-eight inches in diameter and twelve in depth, which is called a "gemming basket;" the native wading up to his knees holds the basket in the water.

A circular turning movement is given to the basket, which is occasionally allowed to tilt below the surface of the water, and in this way the lighter stones slip over the edge, and the heavier ones remain in the basket.

After a good many baskets full of gravel have been washed in this way, the residue, which is found to contain thorianite and thorite and other heavy minerals, is carefully searched for gem-stones.

The number of gems found of insignificant value is extremely large in proportion to that of the choice specimens, so that often a great deal of work is done before there is any prospect of recompense.

When an important stone is discovered there is great excitement among the natives, and many would-be buyers eagerly endeavor to outdo each other in obtaining a bargain. The price asked is generally several times greater than that which is eventually accepted, and by continual bartering the gem changes hands repeatedly.

Also, there are ever ready pilfering fingers to purloin from the rightful owner, or to substitute an inferior stone for one of good quality. The diggers and washers are continually watched to prevent anything of the kind from taking place.

It is a matter of great difficulty for Europeans to obtain details or photographs of the gemming industry, for the natives are very jealous and secretive, and object to company upon their expeditions. They are also exceedingly superstitious, and believe in all sorts of devils and evil omens; they will not even allow one of their own women to go near a gem pit, because she would be sure to bring bad luck to it.

There are several extensive districts in the island where precious stones occur, but the most productive locality is the hilly country of Saffragan, the chief town of which is Ratnapura, or in other words "the city of rubies."

Nearly all the different kinds of gems are found occurring together, the exceptions being moonstones, amethysts, and alexandrites, the last of which are principally derived from Galle.

Fig. 9.—Gem Pit Showing Primitive Crane and Pool at Which the Earth is Washed for Gems.

Fig. 10.—Native Gem Cutters at Work With the Overseer Watching Them.

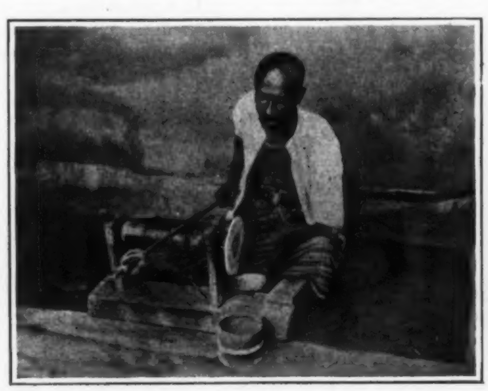


Fig. 11.—A Moor Lapidary, Ceylon, With His Simple Apparatus.

Fig. 12.—The Gems of Ceylon Are Recut in Europe by Skilled Lapidaries.

The natives have a great prejudice against sending gems out of the island in the rough state, and always cut and polish them locally. This is due to their anxiety to see exactly to what extent the beauty of each stone is developed by the cutting, and thus accurately to estimate the value. They do not care to part with the rough stones, for Europeans to reap the benefit of any increase in value.

The cutting and polishing is done by the Singhalese upon perpendicular leaden wheels, smeared with emery, against one side of which the gem is pressed with the left hand, while the wheel is rotated by means of a bow and cord held in the right. (See Figs. 10 and 11.) The whole apparatus is most simple and primitive, the success of the work depending entirely upon the skill of the operator.

The cutters squat upon their haunches behind the wheels, and sometimes an overseer watches the progress of work to prevent theft. (See Fig. 10.) Much of the cutting is done by the roadside in view of every passer-by, but many little "tricks of the trade" are withheld from public view.

The native gem cutters' chief object is to so manipulate the precious stone that the maximum of size and weight is retained, often to the sacrifice of symmetry and brilliancy. They are wonderfully adept at retaining and regulating the color, which in some gem-stones is not of uniform density throughout, and in dexterously hiding feathers and flaws. Owing, however, to irregularity, and also the want of symmetry and proper proportion, it is generally found that the gem-stones in the "native-cut" condition are unsuitable for the requirements of high class European jewelry. It is therefore necessary, before they can be used for the purpose, that they shall be re-cut by a skilled lapidary with a knowledge of mineralogy and optics.

In principle, the apparatus used by the European gem-cutters is similar to that used by the Moor in Ceylon. The wheel is, however, made of copper and diamond dust, and revolves horizontally instead of perpendicularly (see Fig. 12).

The operator sits at a bench and places the gem, mounted on a small ebony holder, against the surface of the wheel which he rotates by means of a crank held in the left hand. Although the apparatus is simple, much expert knowledge, skill and experience are requisite for success in this extremely delicate and artistic craft.

A Review of Animal Experimentation—I*

Its Benefits to Mankind

By W. B. Cannon, M.D., George Higginson Professor of Physiology in Harvard University, Boston

OBSERVATION AND EXPERIMENTATION.

Two ways are open to us for obtaining a knowledge of Nature: We may merely watch natural events as they occur, or we may arrange conditions so that the events will appear or disappear, or be modified, as we may wish. For example, the growth of wheat we may study carefully in different native surroundings, or we may place the wheat where we can at will examine the effect on it of heat and cold, sunlight and darkness, wind, gravity, drought and the chemicals of the soil, as these various agencies affect its growth and productiveness. The former method is purely observational, the latter is experimental. The experimental method, in which the conditions to be observed are under control, is, in the main, the distinguishing procedure of modern science.

There is nothing mysterious about experimentation. The method implies first that study of natural events suggests certain explanations for their occurrence, as for example, that lime in the soil or high temperature makes hard wheat, and that the cautious person, instead of immediately accepting suggested explanations as true, prefers to put them to test.

Of the two methods of learning about Nature, the experimental has proved much more fruitful than the purely observational, chiefly, I think, because experimentation is concerned with means of controlling natural forces. The different sciences, however, are subject to the application of the experimental method in different degrees. Most subject to it are chemistry and physics, since of all the natural sciences they are most simple. As a result of the employment of experimentation, astounding advances have been made during the past hundred years in chemistry and physics, and in their industrial applications. All about us are innumerable instances of the practical benefits that have flowed from the experimental study of Nature in its physical and chemical aspects. I need mention only the telephone, the telegraph and wireless telegraphy, steam and gas and electric engines, to indicate how prodigious have been the transformations in civilized society wrought by practical utilization of the scientific discoveries.

There are other sciences, however, that do not lend themselves so readily to investigation by experiment. In consequence our understanding of them is still very defective. Some phases of geology, for example, fall into this class. It has been pointed out that we to-day know little more about the mechanism of the volcano than Pliny when he watched the eruption of Vesuvius that destroyed Pompeii. We cannot control the conditions of volcanic action experimentally, and therefore have only the simple observational method to apply.

THE EXPERIMENTAL STUDY OF DISEASE.

In medicine, also, the growth of our knowledge was similarly limited, until about the middle of the last century. Up to that time disease had been studied mainly by observation of sick people. To account for sickness all sorts of theories were advanced, such as bad air, the influence of stars, and mysterious humors and miasmas; but these theories were subjected to almost no experimental test. Of course, the highly complex character of living creatures made the beginnings of experimental medicine difficult, for not only do living beings exist together in very complicated biologic relations, but each one is an extremely complex structure, with obscure processes going on within it. In spite of these difficulties, however, the experimental method began about 1850 to be applied systematically to the study of disease, and during the sixty-odd years since then all manner of medical and surgical problems have been experimentally investigated. What has been the result? According to Osler, the experimental study of physiology and pathology during the second half of the last century did more to emancipate medicine from the routine and thraldom of tradition than all the work of all the physicians from the days of Hippocrates (460 B. C.) to Jenner (1749-1823).

In that marvelous period of transformation of medical knowledge and practice the most fundamental discovery was that of the relation between micro-organisms and disease. Pasteur, whose name will be forever linked with this discovery, was a chemist who became interested in conditions which produce bad taste in wines. In the "diseased" wines, as they were called, he found unusual micro-organisms. "Did they occasion the bad taste?" he asked. To test this idea, it was only necessary to introduce some of these minute plant growths or germs into good wines. This he did, whereupon these wines also were rendered distasteful, and thus Pasteur's idea was substantiated. Later, when his attention was called to a disease in silkworms, he again found micro-organisms present and thought that here, also they might be the source of the trouble. Applying, as before, the test of experiment, he introduced the micro-organisms into healthy silkworms and succeeded in reproducing in them the same disturbance. In this case the disease was no less certainly the product of the germ than the oak is the product of the acorn. The idea that all infectious diseases result from these microscopic invaders was a natural and logical next step. Thus originated the bacterial theory of infection.

This theory was soon tested experimentally by many investigators, who studied not only afflictions of the lower animals, but also those of man. And by the numerous proofs that were accumulated, the theory became so firmly established that we now no longer speak of the bacterial "theory" but of the bacterial or parasitic origin of infectious diseases.

TUBERCULOSIS.

The study of diseases which we recognize in human beings is of special interest. First in importance among these, perhaps is tuberculosis. Klencke (1843) and Villemin (1865) have shown that "tubercle" was infectious by injecting into rabbits tuberculous tissue and sputum and thus inducing the disease, but its real nature was not clear until Koch, in 1882, announced the discovery of the germ always found with the disease, the tubercle bacillus. The proof that this germ is the cause of tuberculosis Koch obtained entirely by carefully controlled experiments on animals. He separated the bacteria from tuberculous tissues, made the bacteria grow "pure" outside the body, injected these pure cultures into healthy animals, thereby causing tuberculosis, and then recovered from their diseased tissues bacteria in all respects like the original. Conclusive proof was thus given that tuberculosis results from growth of the tubercle bacillus. All the preventive measures in our great modern campaign against the White Plague are the outcome of these and other experiments on animals. The sign in the street cars warning against spitting are there because animal tests proved that tuberculous sputum is infectious.

Twenty-six years ago Trudeau observed that rabbits inoculated with tuberculosis recovered if kept in the open air and supplied with abundant food, whereas other rabbits similarly inoculated and placed in unfavorable conditions of light, air and food succumbed to the disease. By these observations belief in the value of dietetic and open-air treatment was confirmed; and the further demonstration of the efficacy of such care of human beings afflicted with tuberculosis has led to its unversal adoption.

What have been the results of these researches on animals? From them we have learned that tuberculosis is not inherited, that it is communicable and therefore preventable, and that in its earlier stages it is curable. In most countries the death-rate from pulmonary tuberculosis has been steadily declining. In Boston, where for twenty years before 1882 (when the tubercle bacillus was discovered) the death-rate had been about 42 per ten thousand, it fell in the subsequent twenty years to 21 per ten thousand. It has since fallen to less than 18 per ten thousand. That decrease has meant a saving of thousands and thousands of human lives in the city of Boston alone. Throughout the civilized world the reduction of mortality has been incalculably great.

The alternative to these happy results has been clearly stated by Trudeau:

"If it were not for the knowledge which science has won by animal experimentation in the field of this disease in the last twenty-five years, we should still be plunged in the apathy of ignorance and despair toward it, and tuberculosis would still be exacting its pitiless toll unheeded and unhindered."[1]

BUBONIC PLAGUE.

Another disease which has brought torment and great disaster to man is bubonic plague. Any one who has read of visitations of this horrifying pestilence knows how mysteriously and how swiftly death spread among large populations, and with what awful terror it was regarded. Defoe, in his "Journal of the Plague Year," in London, tells how the streets became hushed as the infection spread insidiously from parish to parish, how the carts moved about at night receiving the heaped bodies of the dead, and how the bodies were dumped pell-mell and by hundreds into huge pits dug for their burial. Thousands died week after week in the city. In the presence of such tragedy the fright and apprehension of the people caused homes to be abandoned, friends to flee from friends; and when the disease developed, the desperate victims often sought death by suicide or became insane. "People in the rage of the distemper," wrote Defoe, "or in the torment of their swellings, which was indeed intolerable, running out of their own government, raving and distracted and oftentimes laying violent hands upon themselves, throwing themselves out of windows, shooting themselves, mothers murdering their own children in their lunacy." Such was the plague in London in 1665, and such it has been in the great populations of the Orient in which it has so often raged.[2]

The mystery of this frightful scourge was lifted when, in 1894, Yersin and Kitasato discovered the germ, *Bacillus pestis*, which invariably accompanies the disease, and when later Simond and others showed, by experiments on animals, that it was spread among rats by fleas, and could be transferred by these same insects from rats to monkeys. The rat-flea also feeds on man when its natural prey is not available.

*In this paper is summarized evidence which has been presented in detail in pamphlets published by the Bureau for the Protection of Medical Research of the Council on Health and Public Instruction of the American Medical Association. These pamphlets, written by experts in the several fields, are referred to in the present paper and should be consulted by persons desiring further information. A price list will be sent on application to the American Medical Association, from whose *Journal* this paper is here reproduced.

[1] Trudeau: Animal Experimentation and Tuberculosis, Defense of Research Pamphlet II, 1909.

[2] In India alone, in the one year 1905, the number of recorded deaths from plague was 1,040,429.

Thus was established the biologic complex by which plague becomes infectious. The attitude of the entire medical world toward the plague was changed by these discoveries, for they suggested a definite program for checking or even abruptly stopping an epidemic.[3] In former times, when physicians were baffled, the people in their fear resorted to "fortune-tellers, cunning men and astrologers," or placed their faith in "antipestilential pills" and "royal antidotes." What futile weapons to combat fleas and rats. Now traps are set, rookeries and vermin-breeding hovels are torn down, and victims already infected are isolated, so that they shall not be the cause of further infection. Through such measures, where it has been possible to apply them, seriously threatening epidemics of plague have been promptly stopped, and the terror of Black Death has been largely abolished. To experiments on rats, guinea-pigs and monkeys we are indebted for this deliverance.

DIPHTHERIA.

Another disease in which marvelous benefits to human beings have been secured through animal experimentation is diphtheria. The peculiar bacteria of this disease, noted by Klebs in 1883, were separated in pure culture by Loeffler, and were inoculated into guinea-pigs and rabbits. The characteristic whitish, tough membrane formed at the seat of inoculation. Since the bacteria were found not at all scattered through the body, but only where the membrane joined the living tissues, the conclusion was drawn that death of the animals was probably due to a poison or toxin produced by the bacteria and spread through the system by the circulating blood. These experiments on animals established for all time the rôle of the diphtheria bacillus and its toxin in producing diphtheria.

An even more practical discovery in connection with this disease was that of the mechanism of immunity. In 1888, Roux and Yersin found that if bouillon in which diphtheria baccilli have been growing is filtered and injected into guinea-pigs, it is highly poisonous in very small doses. The inference that diphtheria germs kill by producing a soluble poison or toxin was thus confirmed. Two years later, von Behring and Kitasato, by injecting first small, then increasing, doses of the toxin into goats, discovered that the animals became adapted or immune to the poison, and further that the immunity depended on an antidote or antitoxin contained in the blood. And still more important and surprising, they found that blood taken from an immune animal and injected into normal animals would protect these animals against fatal doses of the toxin, or would even cure animals that had shortly before received the fatal dose. If the toxin was mixed with some of the protective blood or serum outside the body, the poison was completely neutralized; and this mixture of toxin and antitoxin, when injected, had no harmful effect whatever.[4]

It is sometimes said by opponents of animal experimentation that the injection of "diseased blood" of an animal into our bodies is loathsome. This feeling, however, indicates an entire misunderstanding of the natural processes by which our bodies are protected against bacterial poison. Our bodies, when we successfully resist a disease like diphtheria, are protected by the development of antitoxin within us, precisely as the bodies of these laboratory animals were protected against increasing doses of toxin. And when we use antitoxin in treating diphtheria we merely take from the blood of a horse, which has been rendered immune by injected toxin, some of the protective substance which the animal has developed and apply it to increase the protective substance which our own bodies are producing.

What has been the practical outcome of these experimental studies of diphtheria? Dr. Park, of the New York City Board of Health, has shown that in 1893 the death rate from diphtheria in nineteen large cities of the world was slightly over eighty per hundred thousand population; in 1895, when the antitoxin treatment was introduced, the rate began to drop in almost all the cities; *and in 1907 the rate had fallen from the eighty per hundred thousand of 1895 to seventeen per hundred thousand.* That this extraordinary change has come gradually is explained by the facts that antitoxin was not at once universally employed, that the value of large doses was not at first recognized, and that the supreme importance of early treatment was not immediately demonstrated. Numerous experiences have shown the marvelous effects of instant injection as soon as the disease appears. In the New York City Hospital for Contagious Diseases among 218 patients treated on the first day there were no deaths.[5] In the Boston City Hospital there have been during the past sixteen years, among nurses, physicians and attendants in the contagious wards, 431 cases of diphtheria. All these persons have received instant treatment; *there has not been a single death.* The figures that have been gathered are on so large a scale, and are so striking and so precise, that it is impossible to misunderstand them. They prove definitely that the antitoxin treatment has saved from death scores of thousands of human beings.

Death from diphtheria was formerly one of the most frightful modes of death, for the growing membrane led to literal strangulation. Here is Trousseau's classic description of the disease as it occurred in children. It was written about 1870:

"The difficulty of respiration increases in severity. Every hour, or every two or three hours, a suffocative fit comes on. The suffocative attacks follow one another more rapidly, and become more and more violent. From time to time the infant, in a state of excitement which is impossible to describe, suddenly sits up, seizes the bed-curtains and tears them with convulsive frenzy; he throws himself on the neck of his mother or of those about him, embracing them and trying to clutch whatever he can as a something to hold by. At other times it is against himself that he directs his impotent efforts, grasping violently the front of his neck, as if to tear out from it that which is suffocating him. The puffy, purple face and the haggard, sparkling eyes express the most painful anxiety and the most profound terror; the exhausted child then falls into a sort of stupor, during which respiration is difficult and hissing. The face and lips are pale, and the eyes sunken. At last, after a supreme effort to breathe, the agonies of death begin, and the struggle ends."[6]

With such distressing scenes in hospitals in which diphtheria cases were received, can we wonder that it was difficult to secure nurses who would remain?

The introduction of antitoxin not only reduced the death rate in the remarkable manner already mentioned, but greatly relieved the distress of the afflicted. The injection of the curative serum soon causes the membrane to roll up, and to be so quickly removed that in most cases the danger of suffocation does not arise. At the meeting of the American Pediatric Society in 1896, when the first experiences with the new treatment were being reported, physicians spoke of the "marvelous" effects they had witnessed, and declared that in years of practice they had never known such surprising results as antitoxin had made possible.[7]

EPIDEMIC CEREBROSPINAL MENINGITIS.

Cerebrospinal meningitis is another disease which has claimed its victims by the scores in epidemics which from time to time have swept through our communities. Its mysterious onset and its dreadful power to kill and mutilate spread consternation whenever it appeared, for the physician was helpless in its presence. About seventy-five of every hundred cases ended in death, and the twenty-five patients who survived were often left blind, deaf, paralyzed or imbecile.

The germ causing this disease was discovered by Weichselbaum in 1887, but it was not until twenty years later, in 1906 and 1907, that Flexner developed an effective treatment. This consisted in producing in the horse an antiserum, in a manner similar to that used for diphtheria antitoxin. The antimeningitis serum was first carefully tested by injecting it into the spinal canal of monkeys previously infected with cerebrospinal meningitis, with the result that the serum quickly restored the animals to health. About twenty-five monkeys were used in the course of the investigation.

Already in nearly a thousand cases of epidemic cerebrospinal meningitis[8] the death rate has been reduced from approximately 75 per cent to about 25 per cent among patients treated during the first days of the illness. And even when patients treated late are included, the mortality is only slightly over 30 per cent.

The reduction of mortality, however, is not the only benefit. The curative serum greatly shortens the duration of the disease, and, what is more important, the patient usually recovers without the deafness, blindness and paralysis, and the impairment of mental power, so often the consequence in untreated patients. Dunn has contrasted the appearance of the wards of the Children's Hospital, Boston, now as compared with the pre-serum days. He writes:

"Formerly there were almost always to be seen wasted little patients lying with head drawn, neck rigid, limbs twisted and paralyzed, head swollen by hydrocephalus, and other painful conditions, and remaining thus for weeks or months until death resulted. Now the little meningitis patients are soon laughing, talking, and playing with other children, and need not be kept along in the hospital."[9]

Surely this direct result of animal experimentation that has already been manifested in saving for useful lives a half-thousand human beings is to be counted among America's choicest contributions to the "relief of man's estate."

PUS AND SURGICAL ASEPSIS.

One of the earliest interests of investigators engaged in experimental medicine was the study of the nature of pus, and of blood poisoning. Pus had been regarded as so necessary for the healing of wounds that its appearance was watched for, and it was designated "laudable pus." Yet accompanying it were much distress and pain and a very high mortality. In our Civil war blood-poisoning (pyemia) was not infrequent, and had a mortality of over 97 per cent. Fifty-one per cent of the men who had the knee-joint opened died of infection, and of those who suffered a fracture with rupture of the skin about 66 per cent died. The abdomen and other body cavities were forbidden fields for surgical interference because death so certainly followed the operation of opening them.

Careful microscopic inspection revealed the presence in pus of numerous bacteria. Might not the bacteria cause the pus? If they were excluded might not wounds heal without becoming purulent? Working on this suggestion and on ideas that Pasteur had expressed, Lister watched the healing of surgical wounds in men, and experimental wounds in lower animals, when access of germs to the wounds was prevented by phenol (carbolic acid) sprays and special dressings. The wounds healed without pus! Later it was found that phenol could be dispensed with, and that soaping and scrubbing the skin, and steam-sterilization of instruments and bandages were sufficient precautions against purulent infection; but nevertheless Lister's studies were the beginning of modern aseptic technic. All the astonishing advances in surgery during the past forty years have been made possible through these studies, which were inspired by the results of Pasteur's experiments on animals and in which animal experimentation played a highly important rôle.[10]

Not only in the development of surgical asepsis, but also in the development of surgical operations have animals been useful to man. The surgeon knows where to approach the brain because the parts of the brain associated with different bodily activities have been discovered through physiologic experiments on monkeys. The restoration of cut nerves and the proper method of suturing them have been learned through a series of physiologic experiments. Many successful operations in the abdominal cavity have resulted directly from tests previously made on animals. The possibility of excising without danger a large extent of the small intestine—an operation sometimes necessary—was thus first demonstrated. Various means of making an artificial opening between the stomach and intestine, when the natural outlet of the stomach is blocked, were also experimentally devised. Proper methods of joining the ends of the severed bowel were, likewise, first shown on animals. More recently, by animal experimentation, the surgery of the chest has been developed; and now apparatus has been invented which permits operations on the heart, the lungs, and other structures of the chest cavity, without the disturbing and possibly serious collapse of the lungs—formerly a constant danger when the thorax was opened. And still more recently, through operations on animals, the surgery of blood vessels has been perfected to such a degree that the effects of dangerous hemorrhage may be readily treated by the transfusion of blood from a friend or relative to the person in need. These are merely illustrations of the immense advances in surgery during the past thirty or forty years which have sprung directly from experimental methods applied to surgical problems. The release of mankind from distress, disability and long-lasting pain, which has been the consequence of these advances, is beyond all calculation.

To be continued.

The International Agricultural Institute at Rome.—Fifty countries are represented at this institute, which has a library of 25,000 volumes, receiving every week as many as 2,000 scientific reviews. The institute publishes a monthly bulletin relating to agricultural statistics, which is now in its third year.

[3] McCoy: The Relation of Animal Experimentation to Our Knowledge of the Plague, Defense of Research Pamphlet XV, 1910.

[4] A large body of knowledge, the science of immunology, has been built on these and other experiments on the resistance of organisms to infection. See Gay: Immunology, a Medical Science Developed Through Animal Experimentation, Defense of Research Pamphlet XVII, 1910.

[5] Park: The Rôle of Animal Experimentation in the Discoveries Leading to Our Present Knowledge of the Etiology, Prevention and Cure of Diphtheria, Defense of Research Pamphlet XXII, 1911.

[6] Trousseau: Lectures on Clinical Medicine, translated by Rose and Bazire, 1, 342.

[7] *Boston Medical and Surgical Journal*, 1896, cxxxv, 13.

[8] This form of meningitis should not be confused with other forms; health board statistics often do not differentiate the various types.

[9] Dunn: Animal Experimentation in Relation to Epidemic Cerebrospinal Meningitis, Defense of Research Pamphlet XXI, 1911.

[10] Keen: Modern Antiseptic Surgery and the Rôle of Experiment in Its Discovery and Development, Defense of Research Pamphlet XII, 1910.

Transporting Materials of Construction by Boat to Western Bank of the Copper River.

Railroad B[..]g

A Remarkable [..] En

By [..] Wi

THE discovery that veins of high grade anthracite coal and copper deposits existed in western Alaska has caused the completion of a railway to the coast, extending to this section of the territory, at a cost of nearly $70,000 a mile. But 193 miles in length, the Copper River Railroad represents the solving of one of the most difficult engineering problems in American railway history. It is the most northern line in America, except the White Pass and Yukon, and Michael Henry, its constructor, also constructed the road over White Pass. The building of this railway through a rugged mountainous region bridging a glacial river, crossing a deep canyon—all the work performed in the cold wet climate of glacial Alaska, is a memorial to the energy and ability of the American engineer.

The climate of Alaska in winter is so variable near the coast, that the mercury may be below zero one day while the next day the ice of the glaciers melts, and with the action of the warm Japan current, fragments fall from them and form icebergs, or ice fields. In summer, the edge of glaciers crumble more rapidly, and for many miles the Gulf of Alaska is covered with drifting masses of ice that is forced up the rivers, entering it by the tides, and often choking the estuary completely.

The Copper River is so located that where it enters the Behring Sea, it passes through several outlet channels separated from each other by low banks of sand washed down the stream when in flood. To build the railroad it was necessary to construct a steel bridge 1,150 feet long across the river. The men erecting the bridge had to struggle in ice-cold water filled with cakes of ice rushing down stream in fields, or singly, with such a force that the supports of the bridge had to be massive forms of concrete, set far below the soft bottom upon the rock bed beneath. Above the surface of the water, the piers must rise fully forty feet, in order that floods, often carrying a dense load of floating ice, might not sweep the structure away.

This bridge had to be built across the river where it makes a double turn between the great living glaciers, Miles and Childs. Both present 300-foot clifflike faces to the water for three miles, and if it were not for the opening between them, the Copper Valley would be, as was once supposed, utterly impassable for transportation. Where the bridge stands, the current often brings down ice bergs, and hurls them against the bridge piers. In addition, these piers must withstand the breaking up of several feet of sheet ice, under enormous pressure, each spring.

No such problem in bridge building has ever been met before. It was a seeming impossibility that faced the engineer. A million dollars—the cost of the bridge—must be risked on the chance that he and his men could build supports which the ice could not demolish. If they failed in this, the $15,000,000 railroad to the copper and coal fields would be useless, for the site of the bridge was the only place where the railway could cross.

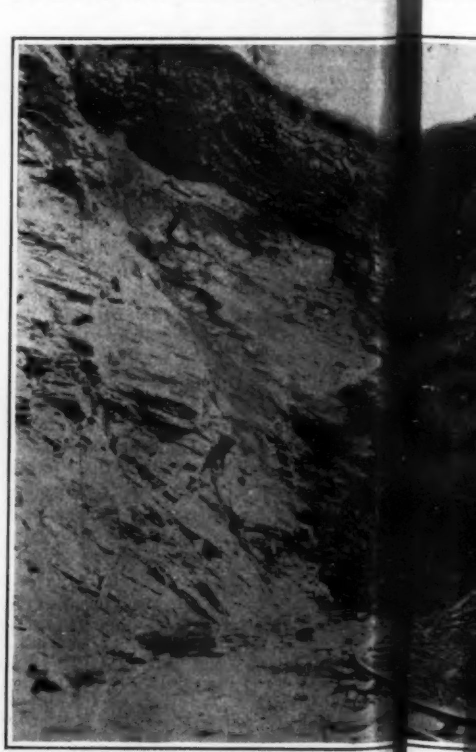
On account of the floating ice no false work could be used. It would require at least two years to build the railway, and to complete the contract within the time required meant that embankment work and track laying must be under way, on the route surveyed on each side of the river, while the bridge was being erected. To carry men, machinery and supplies across the river a ferry boat was built of wood reinforced with steel plates, but often the waves swept over her, sometimes covering the deck with ice and breaking it down in places; then the ferry boat would be fastened to the bank and repaired, to again resume her perilous trips, carrying pile drivers, stationary engines, rails, spikes, ties and other material for the track layers on the west side, while another gang of men formed the roadbed, laid the ties and spiked down the rails, on the roadway approaching the eastern side of the bridge site. This track was necessary to transport the mass of steel girders, and other forms required for the bridge, as well as rails. It required six months to haul these train loads of material from the mill, across the continent to this far-away land of the glacier.

With the eastern section of the railroad completed, a battle between man and nature began—the building of the bridge. It must be completed within six weeks to comply with the terms of the contract. In molding the massive supports of concrete, it was necessary to blast and cut through ice from five to seven feet in thickness before reaching the water. The first work

Driving the La[..] Coppe

was to make the supports. The great piers were [..]he wor
of concrete by means of timber molds built th[..]pper gi
the holes cut in the ice. They were driven fo[..]ere wa
fifty feet through the river buttom to bedrock and [..]hey w
anchored. Included in the concrete filling was a [..] The s
forcement of steel rods. A row of 80-pound rails [..]here w
set one foot apart around each pier. Above the [..]me the
current breakers of the same metal were placed. B[..]nk, th

[..]orary Track for Trains Loaded With Material and Supplies for the Copper River Bridge.



Excavation Work on One [..]by Bla[..]

d B g in Alaska

kable Engineering Feat

By Willey

Miles River Bridge, With Glacier Bank in the Background.

ng the La Copper River Line.

piers were
built th
driven fo
lrock and
ing was a
ound rail
Above the
placed.

he work was half finished water burst out from the pper glacier and the river rose twenty feet in an hour. ere was a thorough test of the piers and the breakers. hey withstood the rush of the water.

The steel of the bridge was ready for erection, but here was no time to be lost. Within an hour of the me the last piece of bridge steel was piled on the nk, the first big girder was in place. Ten and one half days later the first span, 400 feet long, was completed. Nearly forty feet of steel structure a day were built with a single shift of men, day after day, through the storms and the darkness. But the second and third spans were put together faster still. The second, of 300 feet, was built in six days and the third, of 450 feet, in spite of extraordinary difficulties, in ten days. The bridge was completed except a fourth span which was over shallow water beyond the danger from ice.

Some of the adventures of these men who built the bridge across the glacial river deserve mention to show their bravery, nerve and determination. The third span of the Miles Glacier bridge was 450 feet long. The temporary foundation consisted of a thousand piles, driven deep into the bottom of the Copper River, forty feet below the surface. The ice was a solid sheet seven feet thick. Into it the piles were solidly frozen, and the bridge builders began work.

When the spring thaw had begun, the ice-cap, lifted twenty feet above its winter bed by the flood, started moving. It might be but an hour or two's work for the river to wreck the whole span. The emergency was met, as scores of others had been before. The steam from every stationary engine was driven into small feed pipes and every man in camp was put to work to steam-melt or chop the seven feet of ice clear of the piles. And it was done. The holes were kept open through days and nights of bitter cold, and the hundreds of cross-pieces unbolted and shifted while the river rose twenty-one feet. Then began the movement of the span downstream. At first it was but an inch a day; then three or four inches. The melting and chopping went on almost unceasingly. A measurement by the engineers was taken. The unfinished structure was fifteen inches out of line, and it had to be put back.

Anchorages were hastily set into the ice above the bridge. Block and tackle were rigged to them, and while a gang thawed and chopped at the ice around the piles the whole 450 feet of incompleted bridge work were dragged inch by inch back into place. The steel workers began to bolt and rivet the framework of the bridge. So rapidly did they work that the last rivet was driven after eighteen hours of continuous labor. The span was finished just in time.

The steam traveling conveyor, an hour later, wa slid to a temporary resting place on the third pie blocks were knocked out and the third span settled o its concrete bed. At one o'clock the whole 450 feet c piling was washed out, but the bridge was intact.

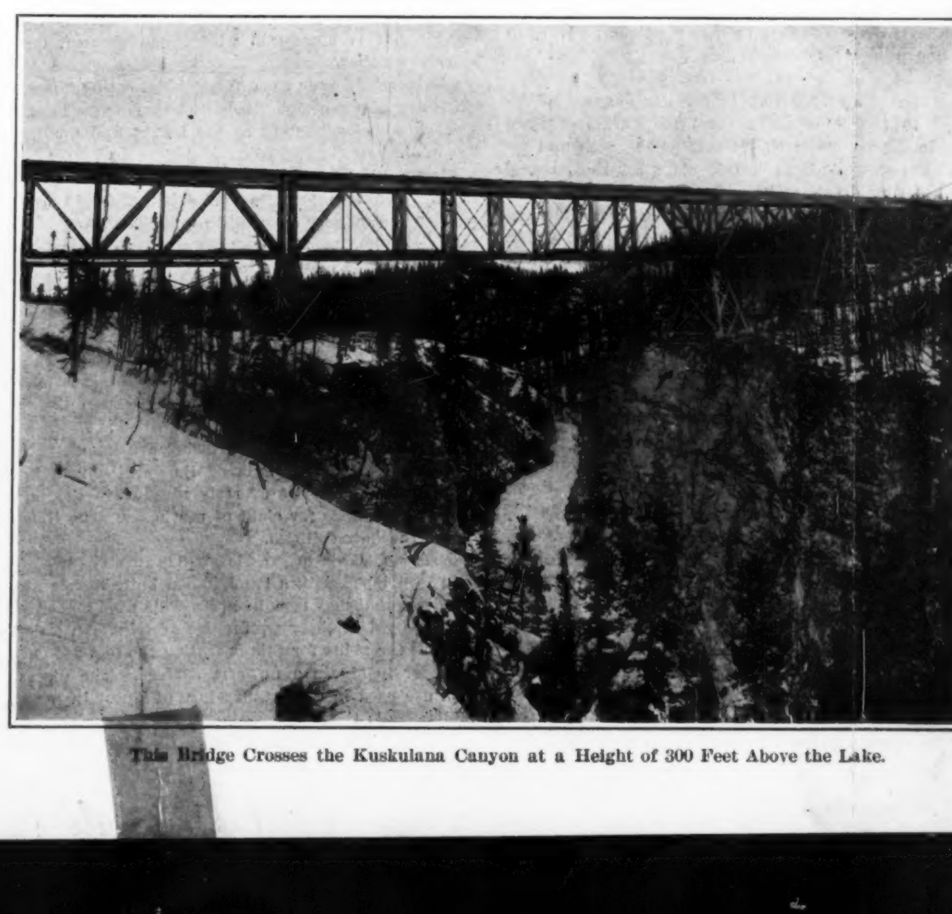
This was but one of the victorious struggles agains the Copper. The engineer, Mr. A. C. Hawkins, ver generously gives the entire credit to the men workin under him:

"They were on the job seven in the morning, n matter what the weather. They worked withou ceasing till the noon whistle blew, then raced eac other to the mess tent. A few minutes later they wer rushing back to the work. And there they stayed unt eleven or twelve at night, until flesh and blood coul stand no more. It was the most amazing exhibition o loyalty, efficiency and endurance I have ever known."

There were many stretches of wooden trestle to b laid and three other steel bridges to be constructe temporary wooden structures being temporarily sul stituted as a time limit of two years had been place on the 193 miles of construction, and this meant un remitting haste. The spring flood with its further del uges of ice-laden waters and driving rains, foun many miles of sinking track, but the work was drive forward. There was track connection with a clay be that made a good ballast, hardening like cement afte it was set in place. While the construction crew an its advance guard of supply men pushed forward, th completed line was being raised several feet above th delta level, and made a permanent roadway with th clay.

The question of carrying construction material b boats was hard to solve. At first they tried towin it up the river in small boats, fifteen or more tough ened river men to a boat. The river was deep, swif and icy cold; the banks of smooth boulders were ofte overhung with tangled cottonwoods, matted low by th deep snows. A boat ascending the river here must b "lined up." Ropes were attached fore and aft, and i was dragged through the icy water by stumbling, strug gling men, while half the crew waded waist-deep in th numbing current to [illegible] off the rocks.

k on One by Bla in Mid-winter.



This Bridge Crosses the Kuskulana Canyon at a Height of 300 Feet Above the Lake.

Above the hundredth mile there was much heavy ...kwork to be done, but the dynamiters and diggers ...re there to do it. Fifty miles of track laid from ... western end of the bridge were deep in snow. To ...nove this snow and ice, a powerful rotary snow ...w with two engines was operated. It made a mile ...l a half the first day, then disappeared, to arrive ... Tickel station, fifty miles inland, thirty-one days ...er. Its last day's run had continued about the daily ...erage for the entire run. In that time the rotary plow was off the track frequently and had to be replaced.

Still another hard fight took place beyond the end of the track. Here food supplies had to be handled by sled, some thirty to eighty miles on the river to the construction camps. The river froze and thawed and overflowed. The ice piled itself into barriers, then sank away to pot-holes filled with many feet of slush and water. Hundreds of tons of brush and the work of many men failed to keep a passable sled road open.

The engineering hero who accomplished a work that seemed impossible to perform, was Erastus Hawkins of New York, who had had experience in railway building and other projects in the far Northwest. This was why he was chosen for the task here described. Exposure and hardship affected his health so that after returning to New York city, Mr. Hawkins died at his home.

Another illustration of the devotion of the engineer to his duty.

Wool Pulling*

How the Fleece is Separated from Sheeps' Hides

By Robert Dantzer

THE skins from which the wool has not yet been re...ved, taken from sheep that have been slaughtered or ...ve died of disease, are received in bales of different ...ights. The Buenos Aires bale contains about twenty ...zen skins and weighs about 1,100 pounds; the Aus...lian bale contains thirteen dozen skins and weighs ... pounds; the bales from the Cape do not weigh over ... pounds. Four skins are folded together with the ...h side out and placed in bales bound with wooden ...ps. The Australian bale is bound with five hoops; ... South American bale with seven. On each bale is ...rked the gross weight and the number of dozen of ...ns. The buyer finds it difficult to determine the ...ld of wool from a lot of skins. The easiest way is to ...n several bales, selected haphazard from the lot be...e the sale, and to examine the skins taken from ... center of these bales. It is in the center of the bales ...t the smallest and least valuable skins are found. ...e skins are graded as follows: A, skins from sheep ...t have been sheared before killing. B, one quarter

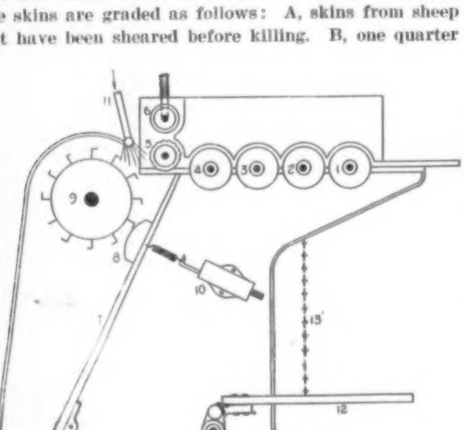


Fig. 1.

... one third wool, [illegible]wool, depending on the ...gth of the fiber. C, full fleece coming from the ...ep to be killed when ready to be sheared. The wool ...pulled from the skins by two methods: 1, by a ...ating process; 2, by stripping.

THE SWEATING PROCESS.

...oaking. This operation is for the purpose of re...ring to the skins the natural moisture lost since ...ughtering the animals. It softens the skin and re...ves the salt added to certain skins for the purpose ...preventing decay. The skins are soaked in large ...angular tanks about 26 feet long, 10 feet wide and ...eet deep. These tanks are sunk in the ground and ...ally made of cement, the water being supplied at ... top and run off at the bottom into a drain. ...en the tank is empty a workman gets into it ... arranges the skins in layers. About 44 pounds ...water is required for each skin, making about 10,- ... pounds of water for 240 skins, the amount usually ... in a tank. The skins are soaked for twelve hours ...summer and forty-eight hours in winter.

...leaning. The object of this operation is to remove ... sand, straw, grass or other impurities from the ...l. The cleaning machines are of different types. ... 1 shows the best type. The skin is laid with the ...l upon the rollers, 1, 2, 3, and 4, which deliver it ...the press rollers, 5 and 6. The wooden roller, 5, is ...rugated. The upper roller, 6, is made of rubber ... the pressure is obtained by springs, as shown. As ... skin comes from the press rollers, 5 and 6, it falls ...the oblique table, 7, which swings on a hinge at the ...er extremity. The rubber band, 8, serves to hold ... skin against the cylinder, 9. The last is pro...ed with steel teeth or with straight steel bands which strike the skin as the roller revolves. The pressure of the skin against the roller can be regulated at 10. The action of the cylinder, 9, is reinforced by a spray of water controlled by the pipe, 11, which removes the impurities. The cleaning operation can be repeated several times on the same skin, as the workman keeps hold of the end of the skin. The pedal, 12, is connected by a chain with a shipper which enables the workman to reverse the machine, causing the rollers, 1 to 6, to revolve in the reverse direction and enabling the skin to be dwawn back for another operation. One man can clean about 600 skins in 10 hours. The water, although charged with impurities, can be saved if desired, but it is first passed through a metal sieve in order to save any wool that it may have carried with it. The wool thus collected is carbonized by the sulphuric acid process.

Resoaking. This operation, which is similar to the first soaking, lasts for twenty-fours hours and is for the purpose of regulating the moisture. In some plants the second soaking is omitted.

Sweating. The skins, after having been drained, are placed on a truck and carried to the oven. These ovens, which are generally sunk in the ground, have each an area of from 430 to 530 square feet and are 6 feet 6 inches wide. Hooks, from 2 to 3 inches apart, are fixed on wooden rails about 5½ feet from the ground. The skins are hung on these hooks by the hind legs. The space of 1 foot between the hooks and the ceiling is necessary in order to allow for the storage of gaseous products and to expose all parts of the skin to the same temperature.

A strong odor of ammonia comes from the ovens, as a result undoubtedly of the special bacteria which exert a destructive action on the hair follicles. The care of the oven is the most important part of the operation. Much experience is necessary in order to determine the time at which the skins should be removed. If they are taken from the oven too soon the removal of the wool will be difficult. On the other hand, if the skins are left too long in the sweating house, putrefaction may set in and the skins lose their value for leather. The duration of the sweating process varies greatly and depends upon the temperature outside. It is longest in winter and shortest during stormy weather.

Classing. As they come from the sweating house the skins are of a greenish shade and very soft. They are first classified according to the length and quality of the wool.

Stripping. The wool is pulled from the skins by hand. For this purpose the skins are laid over a wooden horse, as shown at Fig. 2. The wool is then removed from the skin by means of a two-handled knife, slightly arched and having a saw tooth edge. The workman scrapes the skin with this knife and the wool is thus very easily removed. A number of boxes are placed in front of the stripping horses and the wool is sorted as fast as it is pulled from the skin. The removal of the wool from the legs offers the greatest difficulty, and in order not to injure the leather the skins are submitted to another process called:

Liming. The skins after rinsing are immersed in a large tank containing milk of lime which is agitated constantly by a series of reels running in the liquor. This process lasts for eight or ten hours. The lime destroys the hair follicles.

Scraping. This process is similar to stripping. The skin is stripped with a two-handled knife to remove all the fibers that may remain on it. This wool loaded with lime is used in the manufacture of felts. In order to prepare the skins for this operation the feet are cut off in order to obtain a uniform surface. The pieces of skin are used in the manufacture of glue. In most establishments the next process is:

Drying. The skins from which the wool has been removed are hung by the legs either in the open air or in drying chambers where they are exposed to a circulation of hot air. At the end of several hours the skins are classed according to their shape and condition, after which they are offered for sale. The value of the skin in this condition depends upon the sweating process. Skins that have been damaged are used in the manufacture of glue or for parchment. To facilitate the drying process the wool is passed through iron squeeze rolls to remove the surplus water. The upper roller is covered with felt and driven by friction. The wool is then dried in a machine. In some cases the wool is first scoured, being immersed for twelve minutes in a solution of soda and soap. This solution, containing 20 per cent of soda ash and 1 per cent of soap, is prepared in iron tanks heated by steam to 120 deg. Fahr. The wool is then taken to a circular washing machine in which the water is supplied tangentially. The wool is delivered from this machine onto a

Fig. 2.

central grating. It is then extracted to remove the surplus water and dried in a machine. It is next sorted according to length, quality and strength of the fiber. Where the wool pullery is near a combing mill the wool is taken direct to the latter establishment, because there is a tendency for the wool to become heated and the fiber injured. Some wool pulling establishments tan the skins, while others deliver them ready for tanning. In the latter case the skins are scraped on the flesh side in order to remove the grease and other impurities. They are then washed in clear water and dried in a dilute solution of sulphuric acid to precipitate the excess of lime. A second scraping is followed by a scraping of the wool side of the skin which is then ready for tanning.

THE STRIPPING PROCESS.

This method is used for French or other European skins, yielding leather of the greatest value, the wool being considered a by-product. The skins are bought by the dozen at the slaughter house while the animals are still alive. Upon their arrival at the pulling establishments the skins are subjected to the following operations:

1. *Washing.* This washing is in clear water and has for its object to remove the blood, earth and other impurities from the skin.
2. *Extracting.* This is to remove the surplus water.
3. *Soaking.* This process lasts for twenty-four hours and is similar to that already described, having for its object to soften the skins. The skins are placed on a horse and the feet and head are cut off.
4. *Cleansing.* The cleansing of the wool is effected in the manner already described.
5. *Soaking.* The skins after being cleaned by the preceding process are placed in tanks filled with water.

* Translation reproduced from the *Textile World Record.*

In order to exclude the air the skins are covered with planks on which are placed heavier weights. This second soaking lasts from one to two hours.

6. *Preparing.* The skins are coated on the flesh side with a solution of sulphate of sodium and lime, or with a solution of sulphate of arsenic. The solution is applied to the skins with a rag fixed to the end of a stick. The skins are hung by the legs in pairs on frames provided for the purpose. At least twenty-four hours must elapse before the skin is ready for pulling. Nevertheless they are left hanging for five or six days.

7. *Pulling.* The wool is pulled either by hand, as already described, or by power. In the latter case the Molinier machine is used. It consists of a cylinder armed with helicoidal bars without a cutting edge. The skin held by special clamps is pressed against the cylinder by a rubber-covered roller adjusted by a pedal. Before the wool is pulled it is necessary to remove the preparing solution either by rinsing or wiping.

8. *Rinsing.* The skins from which the wool has been pulled are rinsed in large tanks.

9. *Liming.* The skin is left in a solution of milk of lime for twenty-four hours in order to remove all traces of the wool. The skins are then prepared for tanning by the usual methods. The wool is extracted and then dried. The wool thus obtained is of much less value because it has been affected by the chemicals.

The sweating process gives a better quality of wool and an inferior grade of leather, the skin being treated in order to save the wool, with the skin itself considered a by-product. When using the stripping process the object is to preserve the skin for leather, the wool being a by-product.

A New Method of Color Photography*

A One-Plate Process Without Pigment

The special features of the micro-spectra method of color photography are, first, that by its means pictures absolutely faithful in color, tone, and texture are obtainable by means purely optical without the intervention of any artificial coloring matter whatsoever, and secondly, that it is a one-plate process involving nothing more than everyday black and white photography. A single negative is taken on a panchromatic plate, a lantern slide is made from it and placed in the position of the negative, white light is projected through the apparatus, and the picture, after slight adjustment, flashes out in its true colors.

The theory of the process is a simple one. It consists in producing by optical means a surface composed of hundreds of complete but very narrow spectra, lying next to one another, the spectra being so close together as to render the individual colors indistinguishable to the unaided eye, so that the surface appears to be white. The photographic positive is used as a mask to block out or weaken those colors which are not wanted, the remainder combining to form the picture.

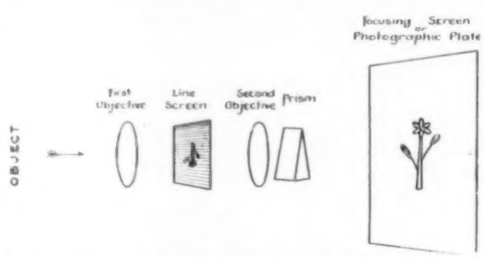


Fig. 1.—General Optical Arrangement Shown Diagrammatically.

The surface, composed of these contiguous narrow spectra, is produced by allowing white light to fall upon a fine line screen, of which the opaque lines are three times as wide as the clear interspaces, and forming an image on this screen by means of a lens with a prism just in front of it. The prism spreads each white line into a complete spectrum, and is so calculated that the spectra lie next each other on the focusing screen without interspace. If instead of white light falling upon the line screen we allow colored light to fall upon it, only those spectrum colors of which the line in question is composed appear on the focusing screen, the colors which are wholly or partially missing from the spectrum of white light being represented by spaces wholly or partially dark.

In taking the photograph the image of the colored object is projected by means of any ordinary objective lens on to the line screen, the image of which is in turn projected by the second lens with the prism in front of it on to the photographic plate placed in the position of the focusing screen. (Fig. 1 shows diagrammatically the general optical arrangement.) The plate must be approximately equally sensitive to all colors, so that the resulting negative is completely darkened when acted upon by any color in its full intensity, and partially darkened where the incident color is weakened. A lantern slide positive from this negative will, of course, show the reverse effect, being completely transparent where the color has acted with full intensity, of partial transparency where the color has acted less strongly, and opaque where the colors were missing, i. e., in those parts coincident in position with the spectrum colors of white light that were not present in the object photographed. When therefore this positive is placed in the exact position of the negative, and white light is projected through the apparatus, it acts as the desired mask to block out those colors that are not wanted, and the picture is reproduced in the original colors.

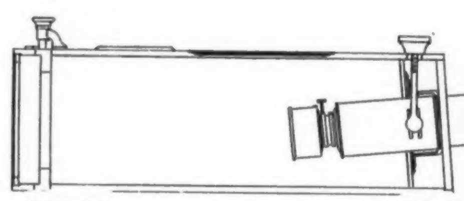
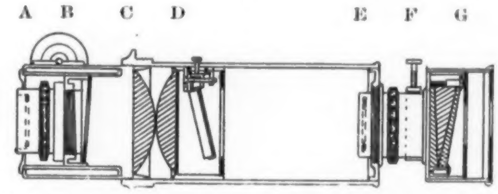


Fig. 2.—Section of Micro-Spectra Camera.

Like so many other scientific problems, however, while the theory was simple, in practice difficulties in the way of the construction of the necessary apparatus (Figs. 2 and 3) arose at every turn, and matters were further complicated by the necessity of keeping the camera within portable limits. To indicate one of the main sources of difficulty, an ordinary glass prism produces a spectrum widely extended in the violet and blue region and crowded up at the yellow and red end, an effect very detrimental to the proper rendering of the latter colors. This was overcome by the use of a compound prism specially computed to give a spectrum in which the colors are evenly distributed, as in a grating spectrum. The introduction, however, of a thick prism of this kind introduced aberrations of all kinds, both in the images of the object and of the spectra, which had to be successively overcome. It was, for example, found necessary to place the line screen (which has 372 lines per inch) at a slant to bring the spectra all over the field sharply into focus; a cylindrical lens is used in front of the prism to correct for astigmatism; the front of the camera is placed at the proper angle to prevent wedge distortion; a narrow prism behind the first objective brings the object sharply into focus, and so on. The objectives used in the camera are two 75 millimeters, Zeiss micro-planars. A field lens is interposed between the first objective and the line screen to direct the light toward the second objective. The whole optical system can be slightly rotated by means of a milled head on the left-hand side of the camera in front; at the back is another milled head securing slight lateral movement, and a lever above the viewing screen (not shown in Fig. 1) permits of a slight backward or forward movement of one half millimeter. These three movements are necessary to enable the lantern plate to be brought to the exact position of the negative, but correct registration is easily secured in a few seconds—the readings can, moreover, be noted on the positive.



A, Zeiss 75 millimeters, micro-planar objective on focussing mount; B, spectacle prism; C, field lens; D, line screen or grating in adjustable frame; E, 75 millimeters micro-planar objective; F, compound prism; G, cylinder spectacle lens, 125-inch focus.

Fig. 3.—Section of Optical System.

Besides the method of viewing the picture on the focussing screen of the camera, which requires a strong artificial light source, the pictures may also be viewed direct on the line screen by means of a magnifying eyepiece, for which purpose ordinary daylight or a weak illuminant suffices. This method in practise does not, however, yield *quite* such good results. The pictures may also be projected in a size of 3-4 feet diameter on a lantern screen.

Until the advent of a really rapid and satisfactory bleach-out paper, there is no possibility of recording the photograph on paper in colors, and since they can only be viewed in or by means of the camera itself, and the latter (which costs somewhere about $300 at present) will always be a somewhat expensive apparatus, even if the optical and mechanical parts can be further simplified, the process is scarcely one that is likely to become general. That indeed was recognized from the start of the experiments. Nevertheless, given the camera, the process is undoubtedly a simple method of color photography to work, and this should encourage many others to take up the new process.

* Reproduced from *Nature*.

Wireless Telegraphy in Railway-ferry Service

By special arrangement between the Prussian and Swedish Railway Departments, the Sassnitz-Trelleborg ferry line, the most recent railway connection across the Baltic, has been equipped with wireless.

The plant installed at Sassnitz Harbor comprises two isolated girder masts 132 feet in height, between which a standard T-antenna has been stretched out. At Trelleborg a standard "umbrella antenna" carried by a girder tower 149 feet in height has been installed.

Electrical energy for feeding the two stationary plants is derived from the existing direct-current systems.

The German ferry-boats "Preussen" and "Deutschland" as well as those placed under Swedish management ("Konung Gustaf V." and "Drottning Viktoria") are equipped with Telefunken stations designed for one kilowatt primary energy, the German boats being fitted with L-antennas and the Swedish with standard T-antennas.

A special point was made of excluding as far as possible any risk of interference by the many wireless stations working in the Baltic. To this effect under normal conditions a wave length of 1,485 feet is used, which is employed only exceptionally by other stations. This in connection with intermediary circuit receivers, has so far insured an absolute freedom from disturbance. In order further to increase the safety of operation, the stations have been calculated so amply as to allow the service to be maintained with one-fourth of the available vibration energy.

The installation of this wireless plant greatly facilitates the whole railway-ferry service. The two stations of Sassnitz and Trelleborg are in fact in a position to keep one another informed of any delay in the arrival of trains, of goods trains to be expected and many other things, while the ferry-boats themselves are able immediately to inform the railway stations or other ships of any unforeseen difficulty met under way, such as fogs or ice, and the resulting delay.

A remarkable case recently occurred on a trip from Trelleborg to Sassnitz: The ferry-boat, at about an hour's distance from Sassnitz, met with massive pack-ice obstructing her course and therefore had to sail backward, choosing another course. Owing to a dense fog falling at the same time, she lost all means of orientation so that the captain finally had to inquire by wireless at Sassnitz station, whether the ship's whistle was heard there, the answer being that the whistle was well to be heard. This showed the ship to be near her destination, and in fact she shortly afterward arrived at Sassnitz Harbor with 1½ hours' delay.

Tests of a Simple Engine*

Taking Steam at Less Than Atmospheric Pressure

By R. C. Carpenter[1]

[The problem of the direct utilization of the radiant energy received from the sun is one whose importance can hardly be overestimated. Our readers will remember an account of Mr. Frank Shuman's experimental solar engine plant recently published in the SCIENTIFIC AMERICAN.[2] *We now bring an interesting account of some tests performed on a low-pressure engine of the type used by Mr. Shuman. The results will perhaps appear somewhat surprising to many engineers, for it is found that such an engine may be operated with remarkable economy.*—ED.]

So far as the writer can ascertain, there are very few data available as to the economy of reciprocating engines when operating with less than atmospheric pressure, although numerous tests have been made of nearly all types of engines under the usual conditions of steam pressure and vacuum. A considerable amount of data is to be found as to the results of steam-turbine tests, especially when of large size, operating with steam of low pressure. The impression generally prevails that the steam turbine produces much higher economy than the steam engine when operating with steam of less then atmospheric pressure.

The investigation, the results of which are given here, cannot be said to prove that the general opinion as stated above is erroneous, but it does tend to indicate that the reciprocating piston engine of small clearances can be operated with low steam pressures and high vacuum with remarkable economy.

The particular engine which was investigated was of the four-valve type and with cam-operated valve mechanism arranged to open and close with great rapidity. The total clearance space was about 1 per cent of the piston displacement. The valves were located so as to make the losses due to clearance a minimum. The results obtained in the investigations could not, in my opinion, have been produced by any engine built ten years ago.

The engine in question was 24 inches in diameter with 24-inch stroke. It was double acting with admission-valve seats on the barrel of the cylinder near the end, and exhaust-valve seats in the heads. This engine was developed to furnish power from steam generated by the heat of the sun in plate boilers which presented a large absorption surface and were designed by F. Shuman.[3] Its general features were conceived by Mr. Shuman. The engineering features were designed and developed by E. P. Haines.

The engine was developed to meet a special demand for a steam motor of small power that would give the highest possible economy with low steam pressure and a high vacuum. Its design and construction were undertaken by Mr. Shuman after he had thoroughly investigated the possibilities of obtaining a commercial engine or turbine which would meet his requirements. The best guaranteed performance for a 25-horse-power steam turbine which he could obtain from any builder was about 60 pounds per brake horse-power per hour with steam of atmospheric pressure and a vacuum of about 28 inches. No such turbine has been built and in the proposals the cost of development would have fallen principally on Mr. Shuman had one been built. As the motor was to be employed for driving a pump, the reciprocating engine at moderate speed possessed many advantages over the turbine. Mr. Haines was quite certain from his preliminary studies that he could construct an engine of about 20 horse-power capacity which would produce a brake horse-power with less than 40 pounds of steam per hour. Several attempts were made before final success was attained; in one of which attempts the entire cylinder and head were lined with soapstone in order to reduce the heat losses. Although this experiment was very expensive, it did not accomplish the desired result. Mr. Shuman only proved by that experiment what was already well known to scientific men, namely, that the principal loss of heat in the steam engine is due to the deposit and re-evaporation of a film of water on the interior walls and not to the loss of heat through a good conducting material.

The Engine.—In general appearance the engine was not greatly different from other engines of similar size, except that its working parts were light and it was provided with a rather long connecting rod. It had an overhung crank and an outboard bearing. Its general appearance is shown in Fig. 1. It could be turned readily by hand, showing that the friction loss was small.

The general arrangement of the valve-driving system and the valves can be seen from Figs. 2, 3 and 4. *A* followed by numerals indicates parts of the admission-valve system, and *E* followed by numerals represents parts of the exhaust-valve system. Two eccentrics were used which drove rocker arms, one of which *A*, Fig. 4, operated the steam valves, and the other *E* the exhaust valves. A cross-section of the admission valve and its driving linkage is shown in Fig. 2. Generally speaking, the valves were constructed so as to reduce the clearance space to the lowest possible limit.

The steam-admission valves, two in number, were of the slide-valve type, arranged to move parallel to the axis of the cylinder on a curved seat concentric with the cylinder. The steam-valve stems were driven by cams A_5, lifting A_6, Fig. 3, against the action of a spring. The oscillation vibrated the bell-crank lever of Fig. 2, which motion was communicated by links to the valve A_{10}, Fig. 2, and gave it a sliding motion on its seat. This design afforded steam ports with an opening 20 per cent of the piston area. These are on the top part of the barrel of the cylinder near each end and are provided by this construction with extremely short passages into the cylinder, thus making a small clearance loss.

The exhaust valves in this construction are especially novel; they consist of thin steel plates situated inside the cylinder heads and are vibrated in a plane perpendicular to the axis of the cylinder. Such valves are extremely unusual in the construction of steam engines and their operation was studied with a great deal of interest. In structure the valve was a flat thin disk provided with slots which were made to register with corresponding openings in the seat by the action of the valve-moving mechanism. It worked smoothly during the test; it was tight and its continued use apparently increased its tightness. The fact that it was very thin and that it was held in position by the pressure inside the cylinder, doubtless explains why the results were so good.

The exhaust valve is shown at E_1, Fig. 2, from which it will be noted that the area of the exhaust ports when open is very large. It amounts to 35 per cent of the piston area. The exhaust valves are vibrated by connecting to the eccentric *E*, Fig. 4, through the medium of rocker arms, links and cams shown in Figs. 4, 3 and 2.

The steam pipe is shown in the upper left-hand corner of Fig. 2, where it joins on to the steam chest. The exhaust-steam pipe is shown beneath the cylinders in Figs. 2 and 3.

The Test.—The test of this plant was conducted at Tacony, Pa., by Prof. W. M. Sawdon and myself. Because of the fact that the steam pressure was very low and that the work was done almost exclusively with less than atmospheric pressure, the method of testing which had to be adopted was quite unusual.

The engine was arranged to exhaust into a surface condenser connected to a vertical air pump. The water of condensation was delivered by a special hotwell pump into one of two tanks, which were placed on weighing scales and provided with suitable pipe connections and valves so that one could be filling while the other was emptying. The hotwell pump was provided with a governor for maintaining a constant level in the hotwell. Observations of the water level were also taken by means of a glass gage, and a correction applied for differences of level whenever necessary.

The engine took its immediate steam supply from a receiver 24x42 inches. The receiver was supplied with live steam from a low-pressure solar boiler situated in another building and some distance away, and it also received the exhaust steam from the air pump which produced the vacuum on the system. The live-steam connection from the boiler was provided with a valve by means of which the pressure was maintained constant by hand regulation. The main supply pipe was exposed to the weather, which was quite cold at the time of the test; as a result a considerable amount of water discharged into the receiver from both sources of steam supply, the height of which was determined by a glass gage and was regulated by a valve on a drain pipe. During some tests it was sometimes desirable to drain the receiver when the pressure was less than atmospheric; this was accomplished by connecting the drain pipe to an auxiliary receiver, which was connected to the suction side of the air pump and thereby kept under vacuum.

The steam pressure was measured by a U-tube mercury manometer attached to the steam pipe near the steam chest. This was kept as nearly constant as possible by hand regulation of the live-steam valve controlling the admission of steam into the large receiver. The vacuum was measured by a cistern mercury manometer connected to the condenser.

The temperature of the steam was taken by a thermometer placed in the steam pipe near the cylinder. The temperature of the exhaust was taken by a thermometer well in the exhaust near the cylinder. In general, all thermometers and pressure gages were very carefully compared with standards before and after the test, and the results corrected as necessary.

In order to guard against any water vapor in the discharge from the air pump which should have been charged against the engine, it was condensed, by discharging through a long pipe extending some distance outside the building. It then passed through a trap, was weighed and considered as steam consumed by the engine.

A gasometer was also placed in the air-pump discharge and so arranged that the volume of air pumped in a given length of time could be measured.

Quality determinations of the steam entering the cylinder were necessary in order to obtain accurate results, for the reason that the steam supplied to the main receiver, as already noted, contained a considerable amount of moisture. This problem was a very unusual one, as it required the determination of the moisture in the steam supplied at atmospheric, or less than atmospheric, pressure. In the tests made, the steam pressure varied from slightly above atmospheric pressure to about 7 pounds below.

The scheme of arranging a calorimeter for working under such conditions was quite original and was worked out in detail by Prof. Sawdon. The results which were

* A paper from the Engineering Research Department of Sibley College, printed in *Sibley Journal of Engineering*, May, 1912.

[1] Professor of Experimental Engineering, Sibley College, Cornell University, Ithaca, N. Y.

[2] September 30th, 1911, p. 291.

[3] See SCIENTIFIC AMERICAN, September 30th, 1911, p. 290.

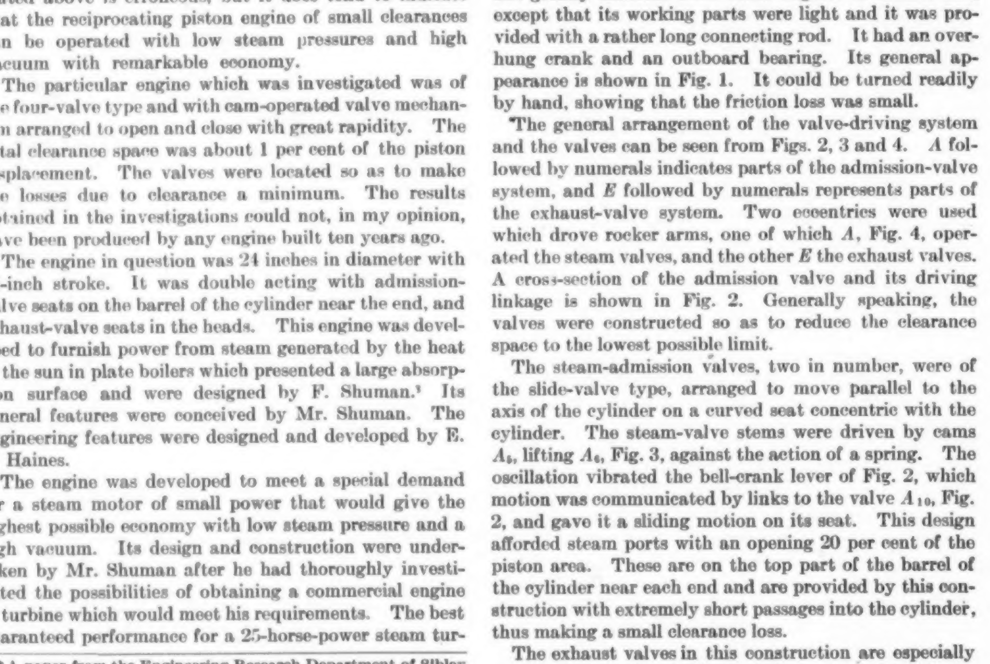
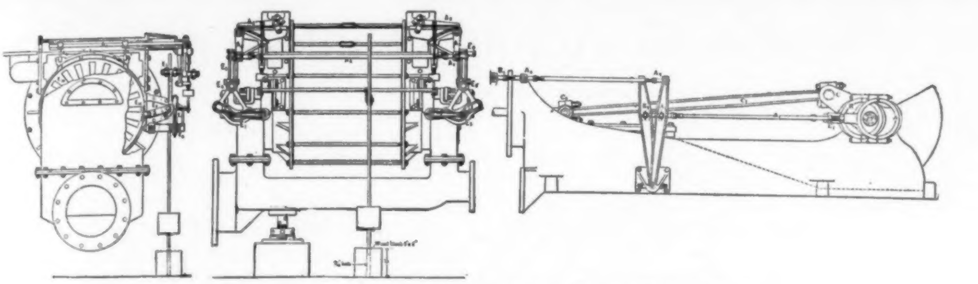


Fig. 1.—The 20 Horse-power Shuman-Haines Low-Pressure Steam Turbine.



Figs. 2, 3 and 4.—Elevations of the Shuman-Haines Engine.

(End view with section through exhaust; side elevation of cylinder; elevation of frame and eccentrics.)

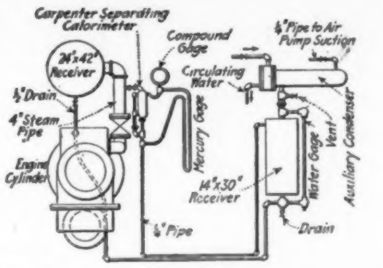


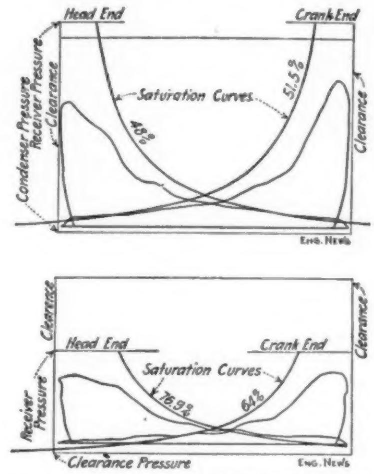
Fig. 5.—Diagram of Connections; Separating Calorimeter for Steam at Less Than Atmospheric Pressure.

obtained were proved, by subsequent tests, to be quite accurate. A separating calorimeter was connected in an auxiliary steam line extending from the main steam pipe to an auxiliary receiver, on which the same vacuum was maintained as on the engine, and through which a fair sample of steam could be drawn by suction. The scheme adopted is shown diagrammatically in Fig. 5. The quality of the steam in most of the tests which I conducted, did not differ greatly from 96 per cent. In a few of the tests conducted with very low pressures the quality approximated 90 per cent.

Indicator diagrams were taken during the test, special springs being carefully calibrated for the pressure conditions under which they were operated. Fig 6 represents the type of indicator diagram which was obtained when the entering steam, as measured in the receiver, was about ½ pound above that of the atmosphere. Fig. 7 represents the form of diagram when the initial steam in the receiver was about 7 pounds less than that of the atmosphere. On both the diagrams submitted, a saturation curve is drawn as a reference line. It will be noted that the expansion line is a long distance from the saturation curve at the point of cutoff, especially for the case of the higher steam pressure. However, it will be noted that these lines intersect before release, indicating that the moisture during expansion had re-evaporated.

With steam about 1 pound above atmospheric pressure and with a vacuum of 28 inches, the engine required 31.6 pounds of steam per brake horse-power-hour. With the same steam pressure, but with a vacuum of 28.8 inches, steam consumption was 28.8 pounds per brake horse-power-hour. These two tests indicate the very material effect of a high vacuum under such conditions of pressure.

With a steam pressure of about 8 pounds absolute (6.75 below atmosphere) and 27 inches vacuum, 37.8



Figs. 6 and 7.—Typical Cards from the Shuman-Haines Low-pressure Engine.

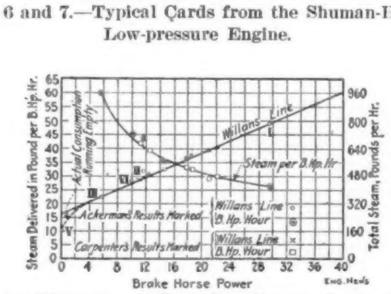


Fig. 8.—Diagram of Test Results on Low-pressure Engine.

pounds of steam were required per brake horse-power-hour. With the same steam pressure but with a vacuum of 28.66 inches, 35.7 pounds of steam were required per brake horse-power-hour.

As compared with the Rankine cycle, the efficiencies vary from 43.8 to 52.4 per cent, depending on the load and steam pressures. On the whole, the results will certainly compare favorably with any published results of any small steam turbines which I have seen.

An independent test of the same engine was made by E. P. Haines a few weeks previous to the tests made under my supervision, and these tests showed substantially the same results.

A. S. E. Ackermann, a noted mechanical engineer of London, England, made a series of independent tests on this engine a few months later than those which I have reported. Mr. Ackermann sent me the general results of his tests and also a diagram on which he had plotted his results and those which I obtained. His diagram is appended (Fig. 8). This diagram was constructed by using the total brake horse-power as abscissas and the total water consumption as ordinates. The plotted results all fall remarkably near a straight line. The fact that the results of the tests of many kinds of prime movers when plotted in a similar way, fall in a straight line, has been proved by numerous experiments, and this empirical law is for this reason a great aid in determining the accuracy of independent tests made on the same prime mover. The fact that my tests and Mr. Ackermann's fall on the same straight line indicate the substantial accuracy of both series of tests. The straight line which characterizes results plotted as explained is frequently referred to as Willan's line, Mr. Willan being a noted English engineer who first pointed out the existence of such a relation. The diagram also shows the steam per brake horse-power per hour for different load conditions.

Wires as a Remedy for Defective Acoustics*

By F. R. Watson

In the popular mind, one of the first aids for a hall with poor acoustics is to install a system of wires or strings with the expectation that in some way the defect will be cured. This prevalent idea is doubtless due to the fact that there are many halls where wires have been strung, and people naturally conclude that there must be some merit in the method. As a matter of fact, this popular impression does not seem to be well founded, for the author has inspected a number of halls thus treated, and has found no marked improvement in the acoustics.

Thus, in Dr. Parkhurst's church in New York city where a thin network of silk fibers of large mesh was stretched horizontally about half way between the floor and the dome, there still persisted a reverberation and an echo. In the Royal Cathedral in Berlin, a number of silk cords are installed in a horizontal network, yet the acoustics remain very defective. A fishnet is stretched near the ceiling in one of the court rooms of the Berlin Rathhaus with no benefit to the acoustical properties. The Royal Albert Hall in London has a series of wires installed, and, while the acoustics there are improved, other features than wires have unquestionably produced the effect. The warden of a church in Nottingham, England, writes:

"Several dodges were tried to overcome the (acoustical) defect, such as stretching wires across the nave."

And so on for other cases that might be cited.

The conclusions of the author in regard to the inefficiency of wires have not always been in accord with the opinions of the auditors in the various halls mentioned. The janitor of Dr. Parkhurst's church, in answer to the question, "Does the net help the acoustics?" replied, "Some says it does, and some says it don't." In the Royal Cathedral in Berlin, according to the attendant's account, the Kaiser thought the wires produced no improvement while the Kaiserin thought they did. The direct question to the attendant as to his own opinion proved very embarrassing and brought only a shrug of the shoulders. Later conversation, however, revealed his conviction that no help had been rendered. In the majority of cases where opinions were asked for, there was a decided expression against the use of wires—"the acoustics are as bad as before," "The wires have not helped," etc.

Some people, however, claim that the method is advantageous, and that the acoustics are really benefitted. The author believes these claims are sincere, but attributes the better hearing to other features than the wires. For instance, the acoustics are usually improved when a large audience is present. Also, the opening of windows produces a good effect. Furthermore, regular attendants in a hall with poor acoustics gets used to the defect, and, by an adjustment of the attention, are able in some cases to subordinate the disturbing factors and hear better than before. Thus, on one occasion the author fixed his attention on a particularly strong echo and was able to hear more distinctly than by listening to the words as they came directly from the speaker. On another occasion in this same hall the leader of the band had great trouble in conducting a certain selection. The piece being played was a xylophone solo with orchestra accompaniment. After some time the leader discovered that he was beating time to the *echo* of the xylophone. The players near the soloist kept proper time, the others near the leader played in unison with the echo. The result may be imagined.

While both observation and opinion indicate that acoustical defects are not helped by wires, it is interesting to look for further confirmation from the standpoint of theory. It is well known that if a loud tone is sung near a piano, certain wires of the latter will resound. Perhaps this phenomenon suggested the use of wires in auditoriums, with the hope that the objectionable sound would be absorbed or broken up in some way. But the conditions for the response of the piano strings are very favorable. There are many wires tuned to different pitches, so that certain ones are in tune, or nearly so, with any tone sung, and these are the wires that resound The wire in the auditorium would respond therefore to only one of the many tones present. To be effective on this score, there would have to be many wires tuned so as to cover a wide range of pitch. Secondly, the piano wire is backed by a sounding board, which absorbs considerable energy and communicates it to the wire. The response is thus very much greater than it would be without the sounding board. The wire in the auditorium has no such sounding board, therefore it absorbs less energy and has less effect on the sound. Finally, the piano occupies a considerable portion of the space of the room and gets energy not only directly, but also by reflection from the near-by walls and ceiling. On the other hand, the wire in the auditorium is small, and is struck by only a small part of the sound waves, direct or reflected, hence has a small chance to help matters. All of these considerations indicate the smallness of the effect to be expected.

One other way in which wires might be beneficial lies in the possible scattering of the sound waves. Here again, however, the small bulk of the wires allows but little effect. The sound waves pass around the wires in much the same way that large water waves on a pond pass by a stake projecting through the surface. It is only when the obstacle has some size compared with the waves that a disturbance is set up. If there were a large number of wires close together, the sound waves would be influenced. In halls, we find usually only a few wires installed, probably with the idea of having them inconspicuous.

From the various considerations mentioned, it is seen that the installation of wires in halls having poor acoustics is without marked effect. While much remains to be done on the problem of architectural acoustics, and though the means of cure can not be specified readily for each case, it is nevertheless of value to know that the installation of wires, as now used, will *not* serve to cure the trouble.

* Reproduced from *Science*.

A Floating Moving-Picture Theater.—A floating moving-picture theater may be seen in the harbors of the Netherlands. The boat is 164 feet in length, has its own electric light plant and is otherwise equipped with the greatest comfort. The venture proved to be a success, as the theater is always well patronized by sailors and residents of the seaport.

Elements of Theoretical Aeromechanics*

Part I.—Aerostatics

By A. F. Zahm, Ph.D.

As some knowledge of the science of equilibrium and motion of fluids is essential to the intelligent study of aëronautics, it seems advisable to present a few of the main principles of that science illustrated by practical applications.

Aeromechanics may be divided into two branches: aerostatics and aerodynamics. Aerostatics is the science of equilibrium of gaseous fluid; aerodynamics is the science of motion and resistance of such a fluid. The two branches may be treated in succession. We shall begin with aërostatics, or, still better, with the general science of fluid statics.

When the fluid is at rest, or moving with equal velocity at every point, it can offer no resistance to change of shape; that is, it can sustain no shearing force. Its pressure against any surface is, therefore, normal to that surface. From this it easily follows that the pressure at any point of a static[1] fluid is equal in all directions; for otherwise a short filament of fluid at the point, extending in any two directions of unequal pressure, would move in the direction of the lesser pressure, since the filament wall can exert no tangential restraining force, being assumed frictionless. Hence the term hydrostatic pressure is commonly used for the stress, or force, acting at a point in a material substance, when no tangential or shearing effort is present.

This hydrostatic condition obtains in natural fluids only when they are at rest or moving without change of shape. In perfect or frictionless fluids, which are purely hypothetical, the pressure at every point is hydrostatic, whether the fluid be still or moving without acceleration; but in natural fluids, such as air or water, if there is shearing motion of any kind, there is sure to be friction, either superficial or internal. This must be reckoned with, and is duly considered in the kinetics of fluids.

For a long time aeronautical investigators believed that the pressure of a gas or of air against a solid surface is perpendicular, whether the fluid be gliding over the surface or not. But it has been amply proved that when relative motion exists between the surface and fluid there is always surface friction, increasing rapidly with the speed, and hence that the force on the surface cannot be normal.

From the assumption that hydrostatic pressure is normal to a surface follows a second principle, viz., that a pressure applied at any point of a static fluid is transmitted undiminished to all parts of the fluid. For suppose a small, open, cylindrical tube to reach from where the pressure is applied in the fluid to where it is transmitted in any direction taken at random. Since the column of fluid in the tube is at rest, the pressures on its opposite ends must balance, if gravity can be ignored, because they are the only lengthwise forces acting on the column, the wall pressure being exactly normal to the length. Hence the pressure at the two points is equal, and the transmission of the pressure is perfect.

As an example of the undiminished transmission of pressure, if a loose-fitting cork in a jug full of water be struck inward by a sharp blow of the hand the bottom will break out; if a plug be driven into a cast-iron shell filled with liquid the shell will burst. Again the water pressure in a faucet is the same as in the far-away reservoir at the same level, if the water is not flowing. So also the pressure of gas or air is constant at all points at the same level in a system of distributing pipes, if the fluid is at rest and at uniform temperature.

The above ignoration of gravity is quite common in engineering, as when computing the pressure of steam in an engine or water in a hydraulic press. But if gravity be taken account of, it is easily seen that the difference of fluid pressure per square unit, at any two levels in the fluid, equals the weight of a vertical column of liquid joining the levels, and of one square unit cross-section.

From the last consideration it follows that a submerged body is buoyed up by a force equal to the weight of the displaced fluid. For the difference of vertical pressure on the ends of any small vertical prism drawn in the body from surface to surface, at different fluid levels, is the weight of a like prism of the fluid; hence for the whole body the difference of the whole upward and downward components of pressure on its surface is the weight of the fluid displaced. Or, otherwise, suppose the body replaced by frozen fluid. This has the same surface pressure, and its buoyance evidently equals the weight of the displaced fluid. Whether the body is submerged or buoyed on the fluid surface, the above argument is valid; hence, in general, the buoyance of a body equals the weight of the displaced fluid. This is Archimedes' principle. Evidently the principle is true for a body immersed in a heterogeneous fluid or in several fluids of different densities.

Since the surface pressures on any immersed body are the same as on a like body of the frozen fluid, whose center of gravity evidently coincides with the center of buoyancy, it follows that the center of buoyancy of any immersed body must be at the centroid[2] of the fluid displaced. The immersed body will, therefore, be in stable, unstable, or neutral equilibrium, according as its center of mass is below, above, or at the center of buoyancy. In a common free balloon, for example, in all ordinary positions, the centroid of the entire mass of envelope and load is well below the center of buoyancy; hence the stability is secure.

In general a floating balloon is not at rest vertically, but rises or falls. If the balloon has surplus buoyancy and a slack envelope, it may rise, enlarging in bulk till the envelope is fully distended or till the air is so light that its displaced mass does not exceed the mass of the balloon. Before this altitude of vertical equilibrium it attained, and before the envelope is fully distended, a slight change of mass may cause a great change of level, because the altering volume of the globe nearly compensates the alteration of atmospheric density. Especially is this true if the framing and cargo have relatively slight bulk, as in a sounding balloon. But it is not well to assume, as some writers do, that the strength of the envelope will prevent the gas expanding, and thereby bring about static equilibrium; for the gas so confined may easily burst the balloon[3]. For this reason, the neck of the envelope below is usually left open, or feebly closed, in order to relieve undue pressure when the bag is distended.

Simple applications of the foregoing principles are sometimes very useful in designing or understanding air craft. In illustration we may take a few examples of balloon construction. But first let it be required to find the resultant pressure at the top of a vertical tube full of light gas, if the tube be open below and closed above.

At the open bottom of the supposed tube the pressure of air and gas are equal. At the top the air pressure is less than at the bottom by the weight of a unit square column of air having the length of the tube, while the gas pressure there is less by the weight of a gas column of the length of the tube. Hence at top the gas pressure exceeds the air pressure by the difference in weight of the columns of gas and air. Thus occurs a resultant outward pressure of the gas, which increases from nothing at the bottom to a maximum at the top of the tube, and at any other point is directly proportional to the distance from the bottom of the tube. This increase of outward pressure is, for hydrogen (roughly), 0.08 of a pound per square foot for each foot above the bottom of the gaseous column, near sea level.

From this simple example it follows that the resultant internal pressure in a hydrogen balloon increases one pound per square foot for each twelve feet above any fixed point in the envelope, the pressure at any given level being everywhere the same. It thus appears that if the envelope be very high, or have a long, vertical neck filled with gas, or if a long, unicellular dirigible rears up, the top pressure may become dangerously great. Ignorance or neglect of this consideration occasionally leads to monstrous and impracticable designs, and sometimes to disaster. Thus a balloon with a long neck has been known to burst at the top, as a cask is burst by pouring in water through a tall, narrow tube. A long dirigible has come to grief by rearing in flight so that the internal pressure caused the prow to explode. Designers of mammoth airships should, therefore, take precautions to ensure their colossal craft against splitting along the back or rearing and exploding at the prow as previously stated.

From the foregoing principles, also, can be computed the bursting pressure of an envelope if the unit tensile strength of its fabric is known. If the envelope is spherical the entire internal pressure on the area of the equatorial circle equals the whole tensile strength of the fabric around the circumference. In other words, to find the bursting pressure divide the entire circumferential strength by the equatorial area; or, more simply, divide twice the strength of one foot of the fabric by the radius of the sphere in feet. By similar reasoning it can be shown that the bursting strength of a cylinder is half that of a sphere of the same diameter, and that its resistance to splitting is half its resistance to tearing across. Of course, the top pressure in a well-designed balloon can never be allowed to approach the bursting pressure so computed, but a large factor of safety must be allowed.

In addition to the foregoing it may be sometimes desirable to know the strength of a long gas bag regarded as a beam, and subject to forces which tend to double it, as in Santos-Dumont's dirigible[4] No. 2. The strength in such case can easily be computed in terms of the cross-section and internal pressure. Without giving the detailed proof, the following theorem may be stated; the breaking moment at any section of a round, inflated beam equals the whole internal pressure on the section multiplied by half the radius.[5]

The unit tensile strength of the fabric may be found by direct breakage in a testing machine, or by bursting spheres or cylinders of it by compressed air, due care being taken to measure the internal pressure and diameter at the instant of rupture. But the practice of novices, in which disks of the fabric stretched over the mouth of a tube are ruptured by fluid pressure, may lead to erroneous conclusions, unless the radius of curvature of the fabric at the instant of rupture be accurately determined, and the fabric itself be guarded from shearing, or cutting, at the clamp. If such measurements are correctly made, the tensile strength can be readily computed from the hydrostatic equations of the preceding paragraph.

The buoyancy of the gas in a balloon is the difference between its weight and that of the air it displaces. If it weighs half as much as air, its buoyancy is one half the weight of said air; if it weighs one fifteenth, its buoyancy is fourteen fifteenths; if it weighed nothing, its buoyancy would be fifteen fifteenths, which is an increase of one fifteenth over that of pure hydrogen. Thus it appears that in point of buoyancy an infinitely light gas balloon or a vacuum balloon would have no very great advantage, at least for ordinary use.[6] For sounding balloons and racers a lighter gas might be desirable if it could be retained.

The height to which a given balloon can rise may be found by dividing the total weight by the total volume of the distended balloon and its load, to obtain the density of the air at the level of balanced flotation, then reading in a table the altitude corresponding to that density. In formulating this rule it is, of course, assumed that no considerable weight of gas escapes during ascent to the level of equilibrium; for every wise aeronaut leaves enough slackness in his envelope during inflation to take up the expansion of the gas during the ascent. The proper volume of gas to start with at the lower level must equal the volume at the upper level multiplied by the ratio of the atmospheric densities at the upper and lower levels, assuming that the gas possesses at those levels the temperature of the environing air, which it may do at night or when shaded by a dark cloud.

If the temperature of the gas be assumed equal to that of the environing air, as might occur in a high-speed metal balloon of good thermal conductivity, it can be shown that the resultant internal pressure, or "net pressure," remains unaltered, however the temperature and barometric pressure of the atmosphere may vary. As this theorem is of some interest in the science of dirigibles, the following simple demonstration of it may be presented, as first given by the writer in the paper above cited:

In the first place, if the atmospheric pressure alone

*Abstracted from the writer's forthcoming popular treatise on aeromechanics.

[1] By static fluid is meant one that is not changing shape or velocity.

[2] Centroid means center of mass, which is commonly taken as the center of gravity.

[3] Exception is made of the case in which the balloon is made of enormously strong and light material for the express purpose of withstanding great internal pressures.

[4] When this spindle-shaped balloon lost pressure it first bent then doubled like a pocket knife.

[5] A proof of this theorem is given in the present writer's paper "Some Theorems in the Mechanics of High-speed Balloons" presented to the International Aeronautic Congress, in 1900.

[6] For a mathematical proof of the impossibility of floating a vacuum balloon see the writer's popular treatise, "Aerial Navigation."

alters, while the other elements[1] remain constant, no change occurs in the net pressure. For the density of the air, and hence the buoyancy of the vessel, changes directly as the barometric pressure; and the vessel will rise or fall to a level where the density of the air is equal to what it was at the first position of equilibrium. But if the density at the new position equals that at the old, so also must the atmospheric pressure, since the other elements have not changed. Hence the net pressure is unaltered, which proves the theorem.

Again, if the atmospheric and gas temperatures alter equally, while the other elements remain constant, no change occurs in the net pressure. For the density of the air varies inversely as the temperature; and the vessel will move to a level where the density is the same as at the first position of equilibrium. But if the density at the new position equals that at the old, the proportionate increment of air pressure must be directly as the increment of temperature, and therefore equal to the increment of gas pressure. Hence the net pressure remains unaltered, which proves the theorem.

Combining the two theorems just established, we obtain the more general one, viz., if the gas temperature of a vertically free balloon keeps pace with the air temperature, no change of net pressure occurs for any thermometric or barometric changes in the atmosphere.

Furthermore, it may be affirmed that if the vessel's bulk varies, while its mass remains constant, practically no variation of net pressure ensues from the bulk change itself. For the pressure increments of the gas and air equal each other, since when the bulk enlarges or contracts the vessel moves to a rarer or denser atmosphere, while the gas pressure changes proportionately, thus leaving the net pressure practically unchanged.

Again, if air is pumped into or out of the balloon, practically no change of net pressure occurs if the balloon is free to alter its pressure accordingly, and if the temperatures of the gas and surrounding air remain equal. For changing the weight of air in the hull causes a corresponding change of atmospheric level, and with it a change of external pressure equalling the change of internal pressure. Practically this means that by pumping air into a balloon or its ballonet the vessel can be brought down from any elevation without altering the net pressure. This and the preceding theorem are rigorously proved in the paper previously cited.

The four theorems just proved assert that, in a high-speed metal balloon (which promptly assumes the temperature of the environing air), practically no change of net pressure can occur from any change of density or temperature of the air, from any enlargement or contraction of hull, or from the alteration of weight caused by pumping air into or out of the hull, providing the vessel is free to float to its level of equilibrium.

To be continued.

[1] The other elements of density are the temperature and percentage of moisture.

Colloids and Colloidal Solutions*

Some Examples from Everyday Life

By Elwood B. Spear

If we stir sugar into a cup of water we make what the scientist calls a solution. It is a homogeneous mixture of water and sugar, that is to say, the smallest portion of the liquid that we can see even under the most powerful microscope contains relatively the same amount of sugar and water as any other portion of the solution. According to the modern theories of the constitution of matter, both water and sugar are present as molecules. These molecules are too small to be seen by the eye even aided by the microscope, and the whole solution, therefore, appears to us to be made up of only one substance. Solutions where the single molecules of the dissolved substance move freely about among the molecules of the solvent are called crystalloid solutions, and the dissolved substance is called a crystalloid. These solutions may be colorless like white sugar dissolved in water or colored like strong tea, but they are always clear and more or less transparent.

Colloidal Suspension.—The water in our rivers and streams in early spring is almost always turbid. This is due to the fact that it contains large quantities of mud and other substances that are divided into very small particles. These particles are held in suspension by the water because their weight is so nearly equal to that of the same volume of water that the whole mass must remain quiet before the mud particles can settle down to the bottom. If the water is moving, the mud particles are carried along with it, and the settling out is prevented by the mixing action of the running water.

If muddy water is allowed to stand, we notice that the largest particles fall out in a few minutes, while it usually takes hours before the water is clear of all the very small particles. This is a general law that for a very finely divided substance suspended in a liquid the larger the particles, the faster they will fall to the bottom. It is possible to obtain particles so small that they do not fall out for several months, and these particles have been given the names of "colloids," while the whole solution is called a "colloidal suspension."

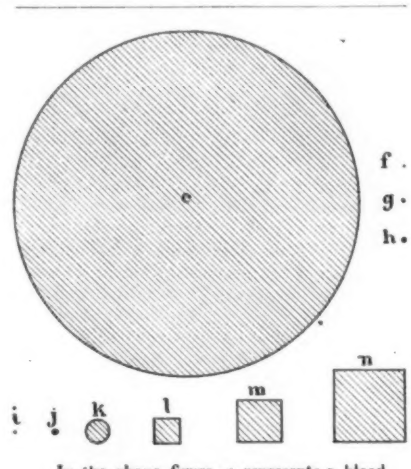
Some of these colloidal particles contain a few, some of them many hundreds of molecules of the dissolved substance. Each particle forms a single community in the liquid and moves as a whole, just as eleven individual players form a football team and make a concerted attack on the opponent's goal, or a thousand soldiers form a regiment and charge a fort.

Colloidal suspensions can be made of many metals, such as iron, silver, gold and platinum, by allowing an electric current to jump across through water between the points of two wires of the metal in question. The particles of a colloidal suspension of platinum made by this process are of various sizes, some of them large enough to be seen with the unaided eye, while others are not much larger than water molecules. Some of the large particles fall out in a few hours, while the extremely small ones may remain suspended in the water for years.

Size of Colloidal Particles.—Suppose one of these particles and the head of a pin were each enlarged in the same proportion until the particles could be seen by the human eye, the head of the pin would then appear as a huge mass of metal as large as a seven-story building.

True Colloids.—If we attempt to dissolve a small piece of jelly in warm water we obtain a solution that appears to be clear. In reality the molecules of the jelly are not single and independent of each other, but have formed groups of two's, three's, ten's, etc., like school children at intermission. We have made here a true colloidal *solution*, which differs from colloidal suspensions chiefly in the fact that particles are soft and plastic, resembling jelly, soap, rubber, etc., while those of the *suspensions* are much harder, like tiny pieces of metal.

Blood a Colloidal Solution.—Most people imagine that the blood is a solution like red ink where every portion of the liquid, however small, is the same color. In point of fact, however, the red color is due to the presence of innumerable small red particles called corpuscles, floating about in a waterlike liquid. These are large enough to be seen by a powerful microscope. In addition to the red particles there is also a considerable number of white corpuscles present in the blood.



In the above figure, e represents a blood corpuscle enlarged 7,000 times, and f, g and h the comparative size of the particles in a colloidal suspension of gold. Now consider that f, g and h are enlarged to l, m and n, then i, j and k will represent the comparative size of molecules of alcohol, chloroform and starch, respectively

Milk.—Milk also is a most interesting colloidal solution containing yellow and white particles. If milk is allowed to stand, the yellow particles unite and float on top, and we call them cream. When the milk sours the white particles unite and we get thick milk. Cream, however, contains both white and yellow particles, because when it is churned we get the yellow particles in the form of butter, while the white ones remain in the buttermilk. If now the buttermilk is allowed to stand, we find that the white particles have united and fallen to the bottom, while the clear amber-colored liquid is left on top.

Colloidal Particles Grow.—The colloidal particles of a gold solution may be caused to unite together and grow larger by violent stirring, just as churning will gather the yellow particles of cream to form solid butter. This uniting of the colloids to form larger particles is called "coagulation," and is produced most easily by violently stirring a hot solution. Some of our readers will remember in boyhood days when obliged to churn how delighted they were when the cream became too warm, because the butter came faster; in other words, the heat had done a part of the churning.

The reason that the flow of blood from a wound can be stopped is because the red particles under the action of the air unite or coagulate and stop up the wound and thus prevent further loss of blood. This is spoken of as the "clotting" of blood.—*Science Conspectus.*

The Effects of Electric Currents on Reinforced Concrete

Alarming news has been published repeatedly of late years on the destructive effects supposed to be exerted by electric currents on concrete and iron concrete. Some experimenters have even asserted that blocks of concrete submitted to a relatively weak current might become loosened sufficiently in their structure to be cut with a knife.

Now a German magazine, *Die Bauwelt*, has addressed a circular inquiry to the experts and engineers of all Germany, with a view to ascertaining whether any insufficiently insulated electric conductors had ever given rise to prejudicial effects on iron concrete constructions. From this inquiry it appears that not a single case of electric currents having in any way endangered a concrete building or some of its parts is so far on record in Germany. The data collected related to a great number of power houses as well as iron concrete masts and all sorts of private houses. Even iron concrete water towers which by their isolated positions and the water contained in their interior, would be particularly exposed to destructive effects, have never shown the least trace of destruction due to the action of electric currents.

It will be remembered that in connection with Knudson's experiments in 1908, a series of concrete and iron concrete blocks were submitted to high pressure in fresh water or sea water, those kept in fresh water being found to be crushed more easily under the action of electric currents than blocks immersed in salt water. On the other hand experiments made in 1910, by W. Gehlet, have shown the prolonged action of strong electric currents to result in desiccation not only of concrete blocks previously kept in water but even of those stored in a dry place. Rammed concrete, however, undergoes an appreciable reduction of its resistance to pressure. The vaporization of the moisture of concrete under the action of electric currents, however, takes place only under greatly exaggerated conditions as compared with those occurring in actual practice. The richer the concrete mixture, the more rapid will be the process of desiccation, while a poorer mixture, on the other hand, has a higher initial strength.

In the case, however, of iron concrete blocks, experiments show, under the action of electric currents, the formation of fissures at the positive electrode. The surface of the iron armature forming the positive pole is covered entirely with rust, whereas a negative iron electrode remains perfectly smooth and the concrete absolutely intact. When using brass electrodes in the place of iron ones no harmful action is observed.

Incidentally, these experiments show concrete to be a conductor "of the second class," its electrical resistance decreasing as the temperature increases and inversely.

Preserving Furs and Woolen Clothing.—Thymol powder has been recommended as one of the best preservatives for furs and woolen clothing. The articles should be sprinkled with the powder and wrapped in paper and then put by in tight boxes.—*Cosmos.*

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

The Drain Water from Refrigerators

We have received the following letter, in which a subject of obvious interest is brought up for discussion. We publish it here in the Correspondence Column and shall be pleased to receive from our readers any comments which they may have to make on the subject. In the meanwhile, one does not hesitate to indorse Mr. T. W. Sprague in the warning note that he has struck. Waste water from any source, however slightly contaminated it may be, is obviously not a desirable material to use for household purposes, least of all for consumption.

To the Editor of the Scientific American Supplement:

You have occasionally discussed the subject of "pure water" for household use. Below I give you a different phase of the question than I have before seen and should be pleased to get your opinion of the matter.

It is well known that the water, melted ice, which passes through the drain pipe of the ordinary refrigerator, carries with it, the congealed odors from the butter, cheese, onions, fish, meats, vegetables, fruits, etc., placed there for the purpose of keeping them cool.

Certain families in my neighborhood save the "refrigerator water," collecting one or two tub-fulls a week, and because it is soft use it in doing the family washing. By the end of the week, this water in the tub, contains great ribbons of white slime made up of the collected odors from the provision compartment of the refrigerator.

Before washing the water is strained, and, of course, much of the coarser particles of slime is eliminated, but the finer particles still remain in the water. A portion of this water is placed in the boiler in which some of the clothes are boiled; the clothes are then thrown into a tub and washed and then run through the wringer into a second tub of the same kind of water used as a rinse or bluing water. After rinsing and bluing and being run through the wringer, they are hung on the line to dry. Now it seems to me that this last rinse or bluing water must contain a great deal of the finer portions of the slime not eliminated when the water was first run through the strainer and which I believe is a slow poison. The underclothing, night shirts, socks, etc., worn next to the skin, must certainly get the benefit of this poisoned water.

I know of one family who have been using this kind of water for the past two years. Their cistern gave out, and this water was used as a temporary expedient; but as a matter of fact, has been used continuously to the present, and every member of the family has been sick; some of them from the time the water was first used, and others were taken sick later.

There is perhaps no family in the neighborhood who live so hygienically, save in this respect, as the family in question. They use no meat, are vegetarians, have fruit on the table every day in the year and give a great deal of attention to pure air sunshine and cleanliness.

I know of another family who used the water from the refrigerator for both cooking and drinking. They were keeping boarders; one gentleman and his wife who were boarding there were sick all the time they remained in the family. I have reason to believe that quite a good many families are using this kind of water. Should be pleased if you would give this subject a write up.

Yours truly,

D. W. Sprague.

Dissolving Copper in Ammonia

To the Editor of the Scientific American Supplement:

Probably some of your readers interested in chemistry may find use of an observation, new to us, made to-day of a peculiar property of copper.

For some hydro-metallurgic treatment it was desirable to find a way of dissolving metallic copper in ammonium hydroxyde. We found that if metallic copper is placed in a solution of aqua ammonia, and powdered ammonium persulphate is introduced into the mass, the metallic copper enters at once into solution, giving the intense blue color of Schweitzer's reagent. Precipitated metallic copper (cement copper) dissolves as rapidly as it would in nitric acid. This property of which we were not aware, may probably be employed in analytical chemistry to separate copper from other metals. In our case the problem was the separation of cement copper from the metals of the platinum group.

This method of dissolving copper rapidly and in an alkaline solution may find applications in chemical technology, and this is the reason why I take the liberty of communicating our observation to you. Mr. Charles S. Witherell, the eminent electro-metallurgist made the observation conjointly with me.

Newark, N. J. Morton Liebschutz,

Chemist to Balbach Smelting and Refining Company.

Science Notes

The Weight of Animals' Stomachs.—In a recent issue of *Comptes Rendus* M. A. Mangin reports on some observations which he has made regarding the weight of the stomach of various mammals. He has extended his observations over 280 animals, weighing the stomach, empty of food, and determining its proportion to the total body weight. He finds that the smallest stomachs are those of insectivorous animals, with a mean weight of a quarter of an ounce; next in order come omnivorous animals, with 3.5 ounces, grain eaters with 6 ounces, and carnivorous animals with 18 ounces. Animals which live on fish stand high in the scale, with an average weight of 190 ounces. Far the greatest capacity, however, is shown by herbivorous animals, whose stomachs weigh on an average no less than 1,600 ounces. Expressed as percentage of the body weight, that of the stomach ranges between 5.8 and 9.3, except for herbivorous animals, where it amounts to 14.6. It is worth noting that the proportion of the length of the intestine to the length of the body follows the same order for the several groups of animals mentioned, ranging from 2.5 (insectivora) to 15.1 (herbivora).

Experimental Investigation of the Origin of the Moon's Craters.—By the use of plastic material some ingenious experiments have been carried out to test M. Emile Belot's theory of the origin of the moon's craters. Melted paraffine is poured upon water and when this has nearly set, a fine stream of cold water is allowed to fall upon the surface, which produces a depression and other characteristic features very similar to those observed on the moon's surface. Still better craters are obtained by pouring paraffine upon hot alkaline solution and then allowing a few drops of acid to fall through the paraffine, causing a violent ebullition.

Effect of Microbes on Sterilized Chickens.—Our readers will remember the experiments which M. Cohendy has carried on with chickens raised with scrupulous exclusion of all microscopic germs. The question has arisen what would happen to these birds if various microbes, not necessarily harmful in themselves, were introduced into their system. The experiments carried out to settle this point seem to show that the chickens were not affected in any abnormal way, but seemed to act like any other bird. This result is not by any means self-evident for the presence of one germ might very easily influence the reaction of the system toward other germs.

Decomposition of Water at Ordinary Temperatures by Magnesium.—A. W. Knapp, writing in *Chemical News*, describes a very interesting experiment in which water is decomposed by magnesium at ordinary temperatures. When magnesium is mixed with water, no reaction is observed at ordinary temperatures, although the formation of magnesium hydroxide and the liberation of hydrogen is an exothermic reaction. This is commonly explained by saying that the film of hydroxide first formed covers the metal and retards further action. However, if magnesium powder be added to ten times its weight of water, and then to this mixture such an amount of palladious chloride as contains about one-hundredth part of the weight of magnesium used, a brisk evolution of hydrogen occurs. The magnesium reduces the palladious chloride and metallic palladium is formed, which acts as a catalytic agent. The small amount of magnesium chloride formed possibly also accelerates the reaction at first by dissolving the hydroxide. The temperature rapidly rises until the water boils and considerable white hydroxide is formed. The palladium, which has accelerated the *decomposition* of the water, now accelerates its *formation*, for it is warm, and some of it rising on the bubble-films, which separate the hydrogen from the air, causes the hydrogen to ignite spontaneously.

The Size of Raindrops.—For about two years past the English meteorologist, Spencer C. Russell, has been carrying on investigations on the size of raindrops. The method employed was to catch the drops on a piece of porous plaster plate. The most frequent size for drops is 2 or 3 millimeters in diameter. The figures obtained were as follows: Of a total of 885 drops, 257 were 3 millimeters in diameter, 222 measured 2 millimeters, 175 had a diameter of 1 millimeter, and 107 fell below this limit. Larger drops were scarce, the classes of 4, 5 and 6 millimeters being represented respectively by 73, 44 and 7 drops.—*Prometheus.*

Zinc for Sterilizing Water.—According to a note in *Cosmos*, a very simple and thoroughly satisfactory means of sterilizing water is to place a few granules of zinc in the vessel containing the same. Zinc does not to any appreciable extent dissolve in water, so that there can be no objection to its use in this manner.

The New Weight and Measure Regulations in Germany.—The new German Weight and Measure Regulations, making the use of the metric system compulsory in all transactions, went into effect on April 1st of this year. For very small weights as used by jewelers or chemists, a special design is prescribed. The 200 milligramme plates are to be square, the 100 milligramme weights triangular, the 50 milligramme weights hexagonal; the 20 milligramme weights are again square, the 10 milligramme weights triangular, and the 2 milligramme weights square.

A City Map for the Blind.—A city map of London has been published which enables blind people to find their way unaided through the highways of the city. The map is constructed on the well-known Braille system; it contains the more important thoroughfares and leading buildings, together with all the necessary directions.

The Smallest Republic.—The smallest republic is not San Marino, as usually supposed, but the diminutive island Tavolara, about 7½ miles off the coast of Sardinia, according to a recent issue of *Deutsche Rundschau für Geographie.* This island is only 1$^1/_5$ miles wide and its whole population numbers but 55. In 1836 Tavolara was granted independence by Carl Albert, and a certain Barteleoni assumed the title of king under the name of Paul I. At his death in May, 1882, he expressed the wish that the people should become self-reigning. In 1886 the Tavolarians proclaimed the republic, and according to their constitution a president is elected every ten years.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, JULY 13, 1912

Published weekly by Munn & Co., Inc. Charles Allen Munn, President
Frederick Converse Beach, Secretary and Treasurer;
all at 361 Broadway, New York

Entered at the Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876). . per year $5.00
Scientific American (established 1845) . . . . " 3.00
American Homes and Gardens . . . . " 3.00
The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application.
Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 361 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

TABLE OF CONTENTS

PAGE
Considerations Before Opening Mines.—By Arthur J. Hoskin 18
Methods of Testing Coatings for Cement Surfaces.—By Cloyd M. Chapman........ 19
Ceylon: the Island of Jewels.—By Leopold Claremont.—12 illustrations........ [illegible]
Animal Experimentation and Its Benefits to Mankind.—By W. B. Cannon and Prof. George Higginson........ [illegible]
Railroad Building in Alaska.—By Day Allen Willey.—6 illustrations........ [illegible]
Wool Pulling.—By Robert Dantzer.—2 illustrations........ [illegible]
A New Method of Color Photography........ [illegible]
Tests of a Simple Engine.—By R. C. Carpenter.—8 illustrations........ [illegible]
Wires as a Remedy for Defective Acoustics.—By R. F. Watson........ [illegible]
Elements of Theoretical Aero-mechanics.—Part I.—Aerostatics.—By A. F. Zahm........ [illegible]
Colloids and Colloidal Solutions.—By Elwood B. Spear.—1 illustration........ [illegible]
Correspondence........ [illegible]